Total Maximum Daily Load (TMDL) for Nutrients for the Nearshore Waters of Pend Oreille Lake, Idaho

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TMDL AT A GLANCE:

Waterbody:	Nearshore waters of Pend Oreille Lake, Idaho
Hydrologic Unit Code:	17010214
Criterion of Concern:	Narrative nutrient criterion
Water Quality Target:	Total phosphorus concentration of 9 µg/L (with an action threshold of 12 µg/L)
Designated Uses Affected:	Water supply, recreation, salmonid spawning, cold-water biota, wildlife habitat, and aesthetics
Pollutant of Concern:	Concentration of total phosphorus
Source(s):	Runoff from urban/residential development, septic systems
Loading Capacity:	4,588 lb/season
Wasteload Allocation:	0
Load Allocation:	4,588 lb/season
Margin of Safety:	Implicit MOS included through conservative assumptions
Seasonal Variation:	TMDL applies during summer conditions (June through September)

Executive Summary

The Clark Fork-Pend Oreille Basin lies in western Montana, northern Idaho, and northeastern Washington. The Clark Fork River begins near Butte and drains an extensive area of western Montana before entering Pend Oreille Lake, in Idaho, at the lake's northeast corner. The lake is the source of the Pend Oreille River in northeastern Washington, which ultimately drains to the Columbia River.

Responding to citizens' concerns and complaints about increasing growths of algae and other aquatic plants in the Clark Fork-Pend Oreille watershed, in 1987 the U.S. Congress mandated the Environmental Protection Agency (EPA) to conduct a comprehensive water quality study of the basin and to report its findings and recommendations. The result was the *Clark Fork-Pend Oreille Basin Water Quality Study: A Summary of Findings and a Management Plan* (USEPA, 1993). The Tri-State Water Quality Council[1] (TSWQC) is implementing the plan, which focuses on controlling nutrients and eutrophication throughout the basin. Formed in October 1993, the Tri-State Water Quality Council consists of representatives from communities across the three-state watershed and includes citizen groups, local governments, industry, tribes and agencies. Members of the Council are working together collaboratively to carry out the water quality protection measures identified in the Clark Fork-Pend Oreille watershed management plan (USEPA, 1993). The TSWQC developed the *Montana and Idaho Border Nutrient Load Agreement Technical Guidance* (TSWQC, 2001) in response to the plan's objective to protect Pend Oreille Lake's open water quality. The Total Maximum Daily Load (TMDL) presented in this report addresses the plan's objective to mitigate increasing eutrophication along the shoreline of Pend Oreille Lake

Pend Oreille Lake was placed on Idaho's 1994 Section 303(d) list as a "threatened" water body and retained on the 1996 and 1998 lists. Because of this listing, the Idaho Department of Environmental

[1] Formerly the Tri-State Implementation Council

Quality (IDEQ) prepared a problem assessment on the lake (IDEQ, 1999). IDEQ's problem assessment recommended development of a Total Maximum Daily Load (TMDL) for the nearshore waters of the lake, recognizing that a long-term concern about degrading lake water quality remains. This TMDL addresses the objective of the Clark Fork-Pend Oreille Basin plan (USEPA, 1993) to mitigate increasing eutrophication along the shoreline of Pend Oreille Lake and was designed to work within the broader framework of the current lake-wide management plan with a focus on nearshore conditions.

The goal of a TMDL is to maintain water quality standards in the waterbody of concern. Because the applicable water quality standards for Pend Oreille Lake are narrative, it was necessary to identify a numeric target for development of the TMDL. The numeric target represents a measurable endpoint that is equivalent to attainment of the narrative water quality standard. Past studies indicate that algae growth in the lake is phosphorus-limited. Therefore, the TMDL target is expressed as a total phosphorus concentration. Data collected at several nearshore locations were evaluated to identify appropriate phosphorus target levels. An examination of the occurrence of total phosphorus concentrations indicated that there are two inflection points, 9 µg/L and 12 µg/L, where an increase in the frequency of occurrence of the concentrations requires a significant increase in the total phosphorus level. The primary target of 9 µg/L represents an average concentration throughout the nearshore waters, while the secondary target of 12 µg/L represents an instantaneous concentration used to evaluate isolated conditions represented by grab samples collected during routine monitoring.

A TMDL identifies the total allowable load that a waterbody can assimilate (the loading capacity) and still meet water quality standards. Several representative nearshore areas ("cells") and the loading and water quality conditions of those cells were examined to identify the loading capacity of the entire nearshore area of Pend Oreille Lake under critical summer conditions. These cells are assumed to represent typical conditions occurring in the larger nearshore area. The individual loading conditions and loading capacities for these cells were calculated using steady-state mass balance equations that considered phosphorus loading from nearshore sources as well as loss across the boundary to the open waters of the lake and loss to natural decay and growth. Using equation inputs developed with observed water quality and physical data, loading capacities for each cell were calculated based on the water quality target of 9 µg/L total phosphorus. The individual loading capacities for each cell were then extrapolated to the entire nearshore area to identify an overall loading limit for the nearshore drainage area.

A TMDL is equal to the loading capacity for a waterbody, and that loading capacity is distributed among load allocations to nonpoint and background sources and wasteload allocations to point sources. The overall loading capacity for the nearshore waters of Pend Oreille Lake is 4,588 pounds of total phosphorus per season (June through September). Because no point sources discharge to the nearshore waters, the wasteload allocation is zero. Therefore, the load allocation to nonpoint and background sources is equal to the loading capacity of 4,588 pounds of total phosphorus per season. An implicit margin of safety was included in the TMDL through the use of conservative assumptions. An implementation plan will be developed for the TMDL and will likely include many of the management actions identified by EPA (USEPA, 1993).

1. Introduction: Placing This Report Within a Broader Basin-wide Context

The Clark Fork-Pend Oreille Basin lies in western Montana, northern Idaho, and northeastern Washington. The Clark Fork River begins near Butte and drains an extensive area of western Montana before entering Pend Oreille Lake, in Idaho, at the lake's northeast corner. The lake is the source of the Pend Oreille River in northeastern Washington, which ultimately drains to the Columbia River (Figure 1[2]).

Environmental concerns in the Clark Fork-Pend Oreille Basin are long-standing. Heavy metals from past mining and smelting activities in the headwaters, and eutrophication caused by excessive nutrients are the two greatest problems at this time. Eutrophication in the Clark Fork River, in Montana, results in abundant growths of attached algae that impair most uses. In Washington the Pend Oreille River is choked with nearly continuous growths of water plants that impede boat traffic and most other uses. An increasing population in the region might exacerbate these water quality problems.

Responding to citizens' concerns and complaints about increasing growths of algae and other aquatic plants in the Clark Fork-Pend Oreille watershed, in 1987 the U.S. Congress mandated the Environmental Protection Agency (EPA) to conduct a comprehensive water quality study of the basin and to report its findings and recommendations. The offices of EPA Regions 8 and 10 were responsible for implementing the Clean Water Act Section 525 Clark Fork-Pend Oreille Basin Water Quality Study; the states of Montana, Idaho, and Washington identified research objectives within their boundaries, conducted the research, wrote reports, and recommended state-specific management actions to meet the basin-wide study objectives. A steering committee provided oversight and reviewed and summarized the three state plans. The result was the *Clark Fork-Pend Oreille Basin Water Quality Study: A Summary of Findings and a Management Plan* (USEPA, 1993). The Tri-State Water Quality Council (TSWQC) is implementing the plan, which was finalized in 1993 following a series of basin-wide public meetings.

The plan focuses on controlling nutrients and eutrophication throughout the basin. Its goal is to restore and protect designated beneficial water uses through four objectives:

1. Control nuisance algae in the Clark Fork River by reducing nutrient concentrations.

2. Protect Pend Oreille Lake water quality by maintaining or reducing current rates of nutrient loading from the Clark Fork River.

3. Reduce nearshore eutrophication in Pend Oreille Lake by reducing nutrient loading from local sources.

4. Improve Pend Oreille River water quality through macrophyte management and tributary nonpoint source controls.

Because of public comments, of which there are no known records, Pend Oreille Lake was placed on Idaho's 1994 Section 303(d) list as "threatened" with no identified pollutant(s). Pend Oreille Lake was retained on Idaho's 1996 and 1998 Section 303(d) lists. Comment letters received by EPA and the Idaho Department of Environmental Quality (IDEQ) during the 1998 listing cycle indicated public concerns over water quality in Pend Oreille Lake and primarily dealt with nuisance algae growth in nearshore areas.

[2] For more convenient printing, black-and-white figures are included in Appendix A.

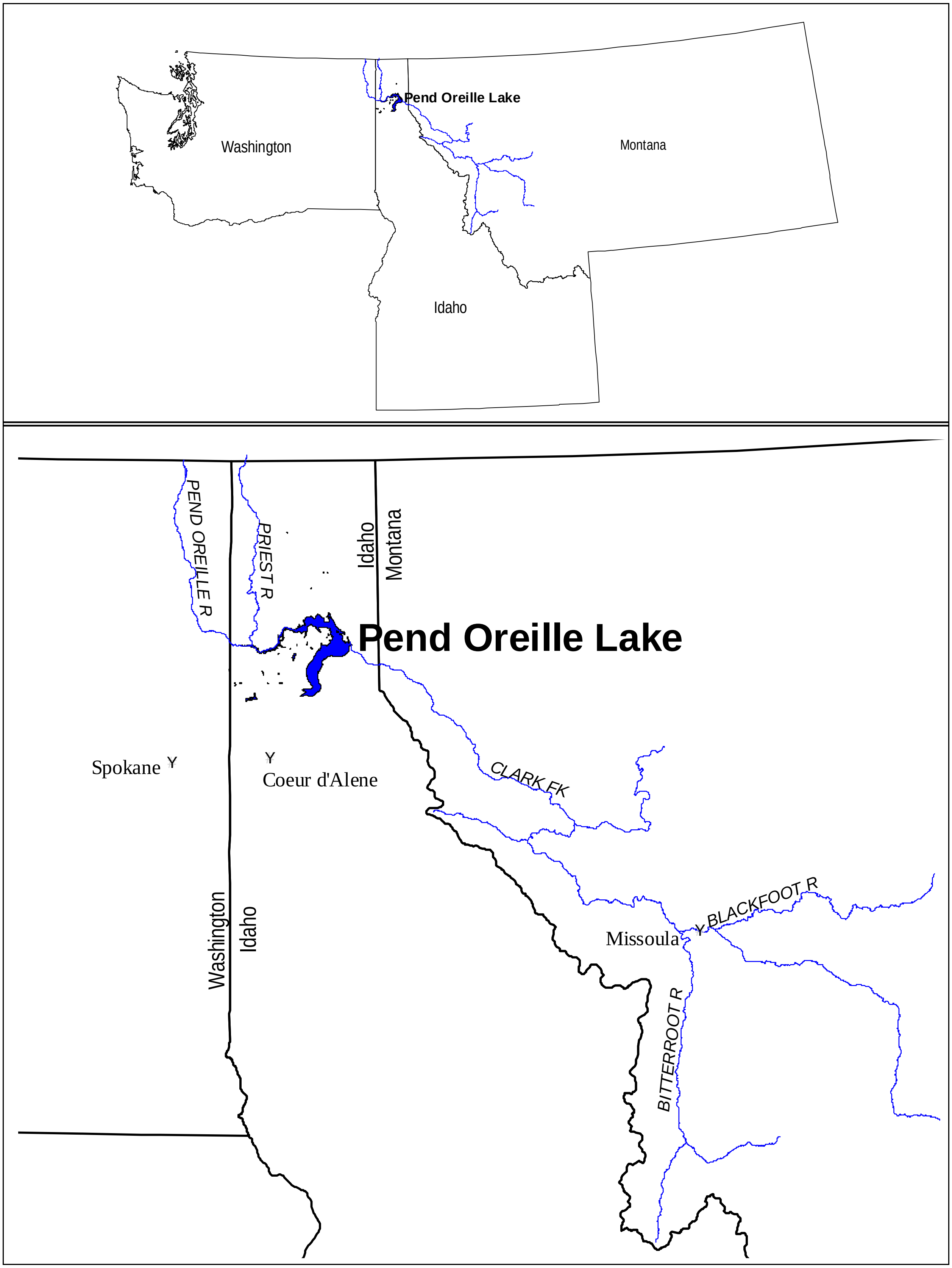

Figure 1. Regional location of Pend Oreille Lake

IDEQ prepared a problem assessment on the lake (IDEQ, 1999) following the 1998 listing cycle. The problem assessment determined that the open waters of the lake did not exceed water quality standards at the time and a TMDL was not warranted. However, IDEQ, in agreement with EPA, recognized the need for professional resource management to protect the open waters of Pend Oreille Lake and supported the TSWQC in its efforts to develop a nutrient management strategy. To this end, IDEQ has participated in the development of a border nutrient load agreement with the state of Montana, as well as a technical guidance document to specifically address nutrients in the open waters of the lake.

The problem assessment also concluded that a nutrient nearshore TMDL should be developed for Pend Oreille Lake to prevent nuisance algae growth and to develop a more robust data set on which to base scientific decisions. The TMDL identifies numeric targets as well as action thresholds that, if exceeded, will prompt resource managers to investigate and document in detail all potential causes of exceedances. The TMDL recommends ongoing nearshore lake monitoring and evaluation of data using an adaptive management approach with feedback loops to help refine action thresholds and targets as needed and to strengthen the overall understanding of nearshore water quality in Pend Oreille Lake.

Of the objectives identified in the management plan (USEPA, 1993) and listed previously, the *Montana and Idaho Border Nutrient Load Agreement Technical Guidance* (TSWQC, 2001) responded to Management Plan Objective 2 by detailing the actions needed to protect the open water quality of Pend Oreille Lake. This report responds to Management Plan Objective 3 by detailing the development of a TMDL designed to mitigate increasing eutrophication along the shoreline of Pend Oreille Lake. It was designed to work within the broader framework of the current lake-wide management plan with a focus on nearshore conditions.

2. Characteristics of Pend Oreille Lake and Watershed

Table 1 summarizes important characteristics of Pend Oreille Lake, the largest and deepest natural lake in Idaho. Pend Oreille Lake is most often divided it into two basins: the deep and relatively poorly flushed southern end and the relatively well-flushed, shallow northern basin. The southern basin contains approximately 95 percent of the lake's volume. From a limnology standpoint, however, Pend Oreille Lake is composed of two different aquatic regimes, the pelagic zone and the littoral zone. The deep pelagic zone represents the open waters of the lake and accounts for about 89 percent of the lake's volume. The shallower, nearshore littoral zone is the band of water along the shore where light penetrates to the lake bottom. This littoral zone accounts for about 11 percent of the lake's volume (USEPA, 1993). According to Hoelscher et al. (1993), it encompasses depths less than 52.5 feet (16 m) and is classified as meso-oligotrophic, meaning it is between nutrient-poor (oligotrophic) and moderately fertile (mesotrophic). This report focuses on managing impacts on this shallow nearshore area.

The Clark Fork River is the principal tributary to Pend Oreille Lake, contributing about 92 percent of the annual inflow (Frenzel, 1991a). Other significant tributaries to Pend Oreille Lake include the Pack River, Sand Creek and Lightning Creek. Numerous intermittent streams also enter at various points around the lake. The Pend Oreille River is the only surface outflow. Literature indicates, however, that Pend Oreille Lake contributes 3.8 to 7 percent of the total recharge for the Spokane Valley-Rathdrum Prairie Aquifer through the poorly consolidated material left by glacial events along its southern boundary (Frenzel, 1991a and Drost and Seitz, 1978, and Painter, 1991, as cited in Hoelscher et al., 1993).

Table 1. Characteristics of Pend Oreille Lake

Characteristic	Value	Source
MORPHOMETRY		
Area of Watershed or Drainage	25,000 mi^2 (67,340 km^2)	TSWQC (2001)
Surface Area	142.5 mi^2 (369 km^2)	TSWQC (2001)
Average Depth - Mean Depth, Northern Portion - Mean Depth, Southern Portion	530 ft (162 m) 95.14 ft (29 m) 721.78 ft (220 m)	Falter et al. (1992) Woods (1991a)[1] Woods (1991a)[1]
Greatest Depth	1,167 ft (356 m)	Falter et al. (1992)
Mean Hydraulic Retention Time, Entire Lake - Mean Hydraulic Retention Time, Northern Portion - Mean Hydraulic Retention Time, Southern Portion	3.2 yr < 1 yr > 10 yr	Falter et al. (1992)
Average Lake Elevation	2,063 ft MSL (629 m MSL)	Woods (1991a)[1]
WATER QUALITY		
Trophic Status	Oligotrophic Mesotrophic (nearshore)	Woods (1991a)[1] Falter et al. (1992)
Water Transparency - Average at Northern Lake Sites - Average at Southern Lake Sites	 18.0 ft (5.5 m) 29.5 ft (9 m)	Falter et al. (1992)
Water Temperature - Range for Open Lake - Range for Nearshore waters	 2.2–22.5 degrees Celsius (°C) 2.2–26.5 °C	Woods (1991a)[1] and Falter et al. (1992)
Dissolved Oxygen	7.8–14.0 mg/L	IDEQ (1989)[1]
Mean Total Phosphorus (Nearshore) - Developed and North Lake Sites, 1989, 1990 - Undeveloped and South Lake Sites, 1989, 1990	 10 µg/L, 7 µg/L 7 µg/L, 4 µg/L	Falter et al. (1992)

[1] As cited in Hoelscher et al. (1993)

The surface inflow from the Clark Fork River and outflow of Pend Oreille Lake at Pend Oreille River are regulated by hydroelectric facilities. Cabinet Gorge Dam, constructed in 1951, is operated by the Avista Corporation and regulates inflows from the Clark Fork River at the Montana border. Albeni Falls Dam, operated by the U.S. Army Corps of Engineers on the Pend Oreille River near the Idaho-Washington border, controls outflows.

Lake levels fluctuate from 10 to 12 ft (3 to 4 m) annually (Falter et al., 1992). In summer, lake levels are controlled at 2,063 feet above mean sea level (MSL) (TSWQC, 2001). Drawdowns begin after Labor Day and lake levels reach a minimum around December 1. This minimum level is normally maintained through winter and early spring, during which time large mudflats are exposed in the northern lake bays. Annual snowmelt increases lake levels in the spring.

Typically, the lake is warmest in early to mid-August (Woods, 1991b; Falter et al., 1992). It is coolest in the riverine section in late January and in the deeper section in March (Woods, 1991b). Thermal stratification develops in the deep sections by early June to mid-July at depths between 26 and 66 ft (8 and 20 m). The thermocline persists until mid-October. Thermal stratification does not develop in the outlet arm because of its riverine character (Hoelscher et al., 1993).

Nearshore Land Use

A band of land surrounding the lake drains directly to the lake rather than through tributary flows. This band represents the nearshore drainage area that affects the water quality conditions of the nearshore areas of Pend Oreille Lake. The dominant land use in this nearshore drainage area is forest (Table 2). As shown in Figure 2, however, there are areas of concentrated developed land in the nearshore drainage of the lake, particularly along the shoreline. Hoelscher et al. (1993) indicates that almost half of all developable land is within 1 mile of the lakeshore, meaning that the development pressure predicted by population growth figures will likely be concentrated fairly close to the lake.

Potential Nearshore Nutrient Sources

The nearshore waters of the lake are likely influenced by sources immediately surrounding the lake or discharging directly to the nearshore waters. Shoreline development as a result of increasing population poses a threat to nearshore water quality. Hoelscher et al. (1993) concluded that at the projected population growth rate the difference between existing conditions (oligotrophic) and less desirable conditions (mesotrophic) would be reduced by approximately one-half in 20 years. Hoelscher et al. (1993) projected a population of 35,081 in Bonner County for 2010; this projected population growth was reached in 1998. Therefore, the growth pattern around the lake has reached the potential for being a threat to water quality. Without nutrient management, excessive nutrients in the nearshore zone could impair the lake's aesthetic quality, recreational uses, and domestic water supplies (USEPA, 1993). Likely sources of nutrients to the nearshore waters are residential development, septic tanks, and urban runoff.

Table 2. Land use distribution within the nearshore drainage of Pend Oreille Lake

Land Use Code	Land Use	Broader Land Use Category [a]	Area (acres)	% of Total
21	Low Intensity Residential	Developed	1,235	2.8%
23	High Intensity Commercial/Industrial/Transportation	Developed	1,014	2.3%
31	Bare Rock/Sand/Clay	Barren	681	1.5%
33	Transitional	Transitional	578	1.3%
41	Deciduous Forest	Forested	77	0.2%
42	Evergreen Forest	Forested	34,749	77.7%
43	Mixed Forest	Forested	769	1.7%
51	Deciduous Shrubland	Shrubland	1,434	3.2%
71	Grassland/Herbaceous	Other vegetated	655	1.5%
81	Pasture/Hay	Pasture and cropland	1,926	4.3%
84	Bare Soil	Pasture and cropland	0	0.0%
85	Other Grasses (Urban/recreational; e.g. parks, lawns)	Pasture and cropland	29	0.1%
91	Woody Wetlands	Wetlands	1,591	3.6%
92	Emergent Herbaceous Wetlands	Wetlands	2	0.004%
TOTAL			44,740	

[a] Individual land use classifications were grouped into broader categories for presentation in Figure 2. Individual categories, not broader categories, were used in the TMDL analysis.

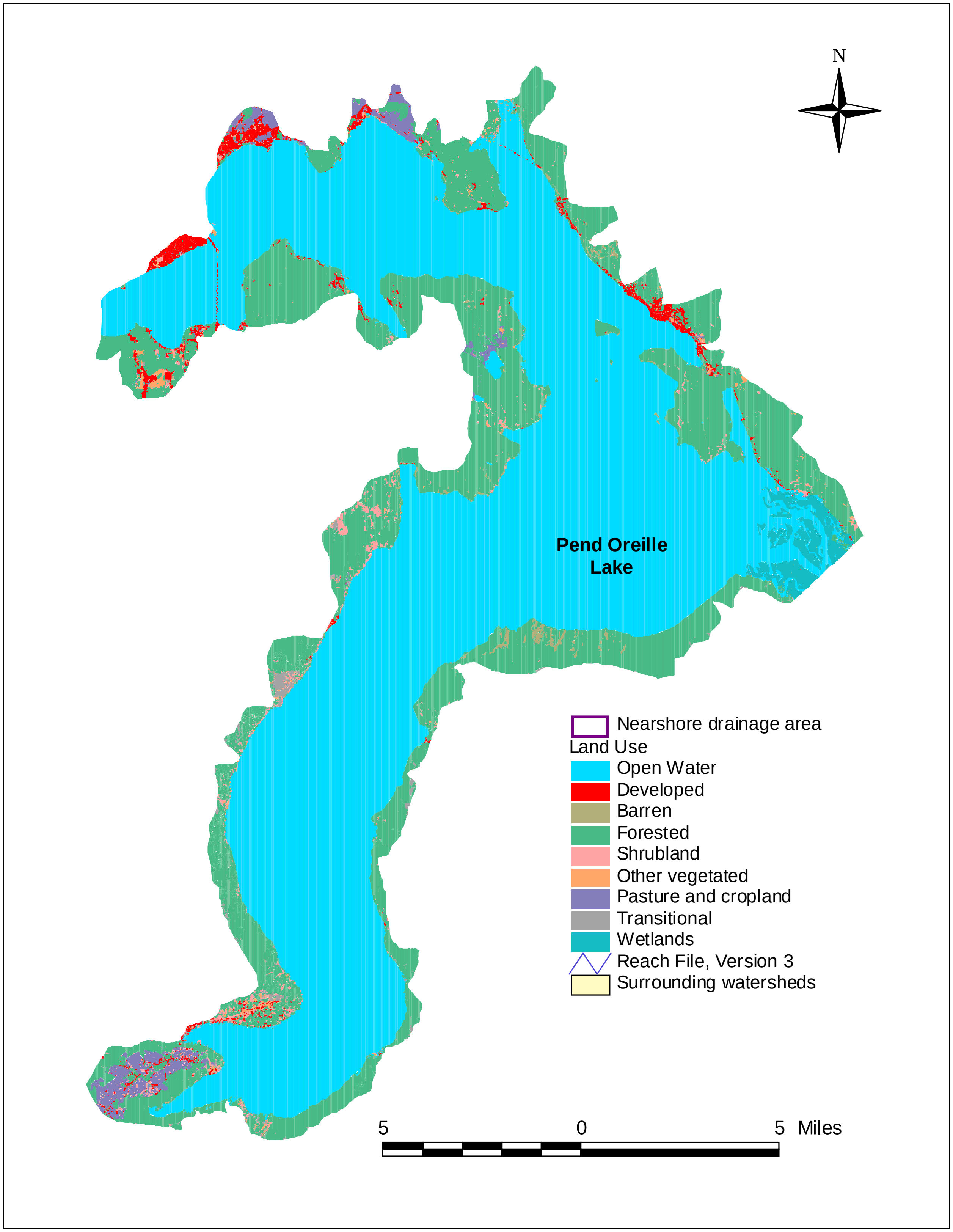

Figure 2. Land use of the nearshore drainage area

3. Applicable Water Quality Standards and TMDL Target

Water quality standards designate the uses of a waterbody (e.g., aquatic life, recreation) and establish water quality criteria necessary to protect those uses. Standards may be expressed as numeric water quality criteria or as narrative standards for the support of designated uses. TMDLs are developed to meet applicable water quality standards, whether numeric or narrative in nature.

In Idaho's *Water Quality Standards and Wastewater Treatment Requirements* (IDHW, 1993), Pend Oreille Lake is designated for cold-water aquatic life, salmonid spawning, primary contact recreation, domestic water supply, agricultural water supply, industrial water supply, wildlife habitat and aesthetics. Pend Oreille Lake is also a Special Resource Water, which means it is a special body of water recognized by the state as needing intensive protection.

The State of Idaho Water Quality Standards (established under Idaho Administrative Procedures Act 58.01.02.200.06) applicable to the Pend Oreille Lake nutrient TMDL include the following narrative description for unacceptable levels of nutrients:

Surface waters of the state shall be free from excess nutrients that can cause visible slime growth or other nuisance aquatic growths impairing designated beneficial uses.

Because these applicable water quality standards are narrative, it is necessary to develop a numeric water quality target for the TMDL. The numeric target represents a measurable endpoint that is equivalent to attainment of the narrative water quality standard. The target identified for the TMDL for the nearshore waters of Pend Oreille Lake is an average total phosphorus concentration of 9 µg/L. In addition to this target, the TMDL establishes an action threshold of an instantaneous concentration of 12 µg/L. (Appendix B provides additional background information on phosphorus targets and the discussion of the technical analysis in Appendix C and Figure C-1 provide more information on the identification of water quality targets for the nearshore waters of Pend Oreille Lake.) The action target of 12 µg/L represents a value that will be used in future monitoring to evaluate attainment of standards based on individual sample concentrations. The monitoring plan will establish guidelines for use of this target in assessing nearshore water quality conditions. The guidelines will identify an appropriate percent and frequency of exceedance of this target that will represent potential impairment of the monitoring site and will prompt control actions to prevent impairment and to restore and maintain water quality standards. The implementation plan developed for this TMDL will define the necessary actions to be taken upon violation of the action target.

4. Existing Studies and Surveys Relevant to the Nearshore Zone

Pend Oreille Lake has been the subject of considerable research. Chapter III of the Montana and Idaho Border Nutrient Load Agreement (TSWQC, 2001) concisely summarizes the existing studies within the context of open lake water quality. Beckwith (1989) and Siefert (1989) also provide a summary of previous water quality studies conducted on Pend Oreille Lake. Appendix D of this report provides a summary of reports reviewed and used in the development of this TMDL. Few of the existing studies focus on the nearshore zone of the lake.

Falter et al. (1992) conducted the most extensive study of nearshore water quality in Pend Oreille Lake to date. Researchers established 16 sampling stations around Pend Oreille Lake in 1989 and 1990, representing developed and less developed, sewered and unsewered, and sheltered and unsheltered shoreline areas. From each site, water samples were collected monthly and analyzed for nutrients, bacteria, temperature, pH, dissolved oxygen, conductivity, carbon dioxide, and Secchi transparency. In addition, artificial algae substrates (tiles) were attached to the lake bottom in 1 m of water at each site. Periphyton (attached benthic algae) samples were collected at 16 sites from the artificial and natural substrates after a 30-day interval (mid-July to mid-August); nine sites were reset with tiles for a second 30-day interval (mid-August to mid-September). Aquatic macrophytes were collected in mid-August with scuba and dredging to estimate biomass.

Data presented in the Falter et al. (1992) report were used in developing this nutrient TMDL for the nearshore waters of Pend Oreille Lake. The specific data and their use in the technical approach are discussed in further detail in the Technical Analysis section and Appendix C of this report.

5. Technical Analysis

The approach for establishing the nutrient TMDL for the nearshore waters of Pend Oreille Lake was developed to use existing water quality and physical data for the nearshore area and to work within the current management goals for the larger Pend Oreille Lake watershed, with a focus on nearshore sources and features of nearshore areas under critical conditions. With these underlying goals, a simple mass balance approach was chosen to evaluate water quality conditions in the nearshore waters.

Several representative nearshore areas (“cells”) and their loading and water quality conditions were examined under a conservative set of assumptions to identify the loading capacity of the entire nearshore area of Pend Oreille Lake under critical summer conditions. These cells are assumed to represent typical conditions occurring in the larger nearshore area. The individual loading conditions and loading capacities for these cells were calculated using steady-state mass balance equations that considered phosphorus loading from nearshore sources as well as loss across the boundary to the open waters of the lake and loss to natural decay and growth. Using equation inputs developed with observed water quality and physical data, loading capacities for each cell were calculated based on the water quality target of 9 µg/L total phosphorus. The individual loading capacities for each cell were then extrapolated to the entire nearshore area to identify an overall loading limit for the nearshore drainage area. Appendix C contains further details on the technical analysis applied for the development of the TMDL for the nearshore waters of Pend Oreille Lake.

Sites used for the development of the nearshore cells were selected from the 17 sampling sites in the Falter et al. (1992) study based on such factors as availability of water quality data, location, depth of nearshore waters, and land use of watershed draining to the site. Figure 3 shows the location of the six sites selected for development of nearshore cells for use in the TMDL analysis, and Table 3 lists and provides characteristics of the sites. Appendix C contains more information on the selection of the TMDL analysis sites.

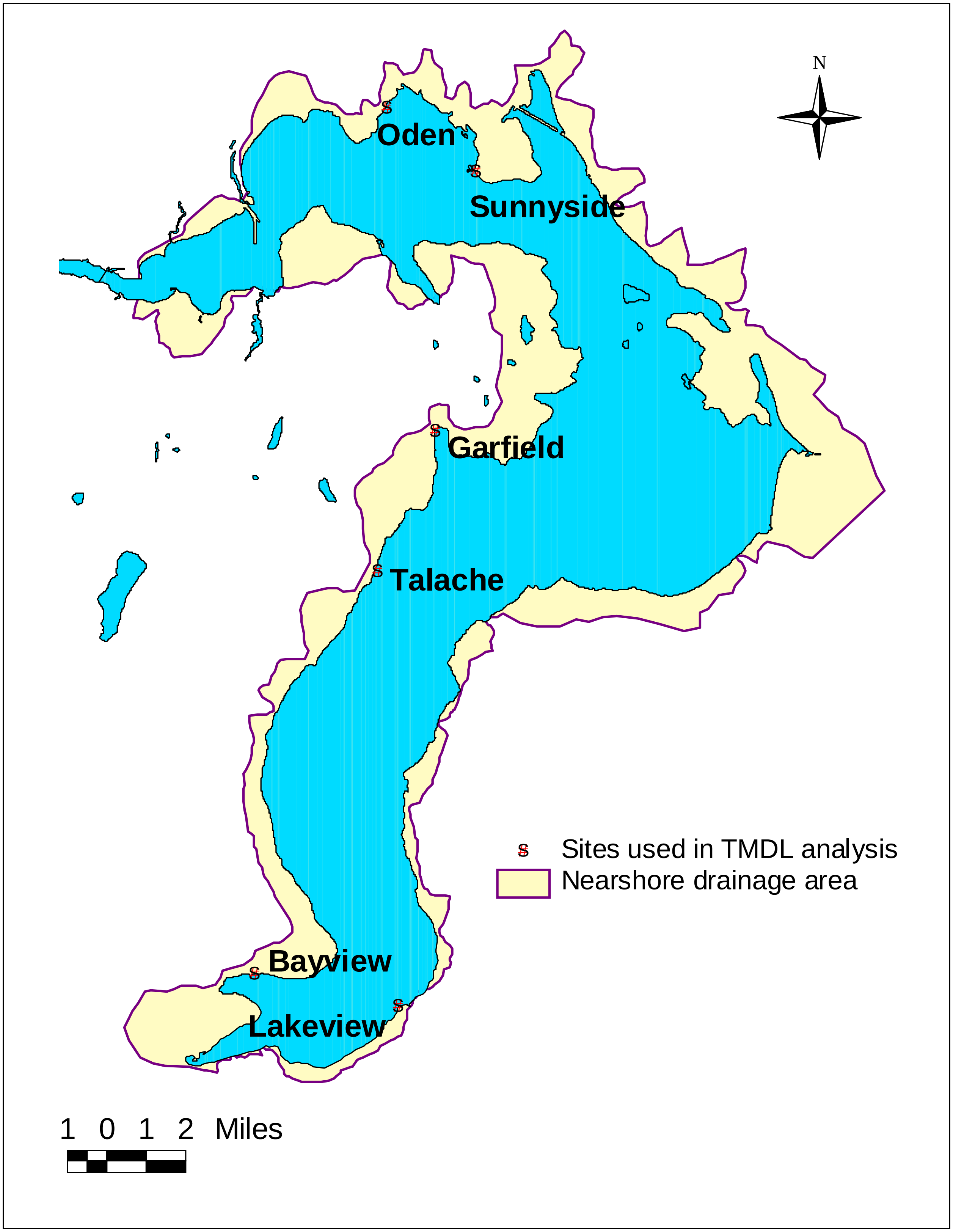

Figure 3. Location of nearshore sites used in TMDL analysis

Table 3. Characteristics of nearshore analysis sites

Nearshore site	Location[a]	Drainage area (ha)[a]	Max. TP (µg/L)[a]	Avg. secchi depth (m)[a]	Development status[a]	Land uses
Oden	North	2,036	11	2.98	Developed	Commercial/industrial, residential, pasture, shrubland, forest
Sunnyside	North	412	11	6.14	Undeveloped	Pasture, shrubland
Garfield	Middle	1,874	7	7.75	Developed	Residential, grasslands, pasture, forest
Talache Landing	Middle	2,085	9	7.68	Undeveloped	Shrubland, grassland, forest, pasture, transitional
Bayview	South	2,084	7	8.95	Developed	Residential, forest, grassland, pasture, transitional
Lakeview	South	557	8	9.0	Undeveloped	Forest, transitional, pasture, shrubland

[a] Based on information contained in Falter et al. (1992).

Guiding Assumptions

The following assumptions guided development of the total phosphorus TMDL for the nearshore waters of Pend Oreille Lake. Additional assumptions associated with the technical analysis are included in the Technical Analysis section and Appendix C.

- *Current nearshore water quality is threatened.* Although Pend Oreille Lake is not specifically listed for nutrients, comments received by IDEQ and EPA from some residents indicate that there appears to be an increasing trend in nuisance algae growth in the nearshore areas. For this reason, IDEQ is establishing a nearshore nutrient TMDL designed to set target levels and action threshold levels for total phosphorus. The TMDL will protect and maintain the current water quality of the nearshore areas while serving as an impetus to begin more in-depth analyses. Given the invaluable resource that Pend Oreille Lake represents to northern Idaho, its immense size, and the scarcity of scientific data, there is a critical need for focused evaluation of the nearshore waters, which this TMDL and accompanying implementation plan will generate.

- *The targets represent the nearshore zone of the lake.* The TMDL is established only for loading that enters the nearshore zone of Pend Oreille Lake. The nearshore zone is represented by the littoral zone, i.e., the band of water along the shoreline where light can penetrate to the bottom.

- *The focus of the nutrient target is protection of the lake's nearshore waters.* The open waters and nearshore waters of Pend Oreille Lake require separate management approaches. This TMDL addresses the water quality of and loading to only the nearshore waters of the lake.

- *The border agreement technical guidance (TSWQC, 2001) addresses protection from overall eutrophication.* This nearshore TMDL focuses on shoreline loading, not tributary loadings. The TMDL is developed for critical conditions when it is assumed that the dominant factor affecting nearshore water quality is loading from the immediate nearshore drainage area. *Montana and Idaho Border Nutrient Load Agreement: Technical Guidance* (TSWQC, 2001) addresses the water quality of and the nutrient loading that affects the open waters of the lake.

- *The lake is phosphorus-limited.* Several studies have concluded that phosphorus is the nutrient most likely limiting algae growth in Pend Oreille Lake (Hoelscher et al., 1993; Beckwith, 1989). Because the impairment concerns relate to excess nutrients causing nuisance algae growth, the water quality target for the nearshore TMDL is expressed as a total phosphorus concentration.

The TMDL

The following sections present the nutrient TMDL for the nearshore waters of Pend Oreille Lake, including the loading capacity and allocations and explanations for the consideration of seasonal variation and a margin of safety in the TMDL analysis.

Total Loading Capacity

An essential TMDL component is identifying and representing the relationship between the desired condition of the waterbody (expressed as the water quality standard) and pollutant loadings. Once this relationship has been established, it is possible to determine the capacity of the waterbody to assimilate nutrients without experiencing impairment through eutrophication. The approach described previously and in Appendix C was used to identify the individual total phosphorus loading capacities for the evaluated nearshore cells corresponding to the 9 µg/L target (Table 4). These individual loading capacities were used with the cells' drainage areas to determine a typical per-area loading limit for the nearshore areas. This loading rate was then used with the drainage area of the nearshore waters to calculate an overall loading capacity (the TMDL) for the nearshore waters of Pend Oreille Lake (Table 4). The TMDL is calculated for the critical summer season from June through September.

Wasteload Allocation

No point sources discharge to the defined nearshore waters of Pend Oreille Lake covered by this TMDL. Therefore, the wasteload allocation is zero (Table 5).

Load Allocation

Because the wasteload allocation is zero, the entire TMDL for the nearshore waters of Pend Oreille Lake is available for the load allocation (Table 5). The load allocation for the nearshore waters is presented as a gross allocation of 4,588 lb/season, applicable to all nonpoint and background sources in the nearshore drainage of the lake. (Note that the TMDL does not include internal lake loading from the pelagic waters.) The distance of the boundary of the nearshore drainage area used to calculate the loading capacity is not consistent around the lake because of topographic variations. However, the area corresponds approximately to a 0.9 mile-wide band of land immediately surrounding the lake (Figure 4).

Table 4. Summary of calculation of loading capacity for total phosphorus for the nearshore waters of Pend Oreille Lake

Site	Loading capacity[a] (lb/season)	Allowable loading rate (lb/acre/season)
Oden	614	0.12
Garfield	371	0.08
Talache	358	0.07
Bayview	561	0.11
Lakeview	107	0.08
Entire nearshore area	4,588	0.09

[a]Appendix B contains further details on the calculation of the loading capacity for the nearshore waters.

Table 5. Total phosphorus TMDL for the nearshore waters of Pend Oreille Lake

Wasteload allocation	0 lb/season
Load allocation	4,588 lb/season
Margin of safety	0 lb/season[a]
Total TMDL	**4,588 lb/season**

[a] Margin of safety was included implicitly through the use of conservative assumptions.

Margin of Safety

A margin of safety (MOS) must be incorporated into the TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can be implicit (e.g., incorporated into the TMDL analysis through conservative assumptions) or explicit (e.g., expressed in the TMDL as a portion of the loadings) or a combination of both.

The MOS was included in this TMDL implicitly through a series of conservative assumptions related to the estimation of the existing loading for the TMDL. The conservative assumptions include the following:

- *Use of lower phosphorus export coefficients for land uses draining to the nearshore cells.* Several export coefficients for various land uses are available in literature, including some site-specific studies. Site-specific export coefficients for the Pend Oreille watershed are included in Hoelscher et al. (1993). These values are lower than other available export coefficients for similar land uses. Using the Hoelscher et al. (1993) values produced lower estimated existing loadings entering the nearshore cells. The mass balance approach inherently links the estimated existing loading entering the cell to the observed phosphorus concentration of the cell. With that established relationship, the mass balance equations are then used to calculate a loading capacity corresponding to the TMDL target concentration. Therefore, if it is assumed that the incoming load that corresponds to existing conditions is lower, the resulting loading capacity is lower and more stringent.

- *Use of conservative assumptions concerning initial mixing within nearshore cells.* The TMDL is developed for critical conditions, which is a required element of a TMDL. In this TMDL, however, the critical conditions established were conservative. The TMDL assumes persistent summer, quiescent conditions with no wind mixing and no lake-to-cell mixing. These conditions are not likely to occur often and therefore are considered conservative.

Critical Conditions

Critical conditions for the nearshore waters of Pend Oreille Lake are conditions under which there is maximum potential for aquatic growth. Those conditions occur during summer months when there are warmer temperatures and less mixing than occur during the rest of the year. To focus on these critical summer conditions, the TMDL was based on data collected during the summer months.

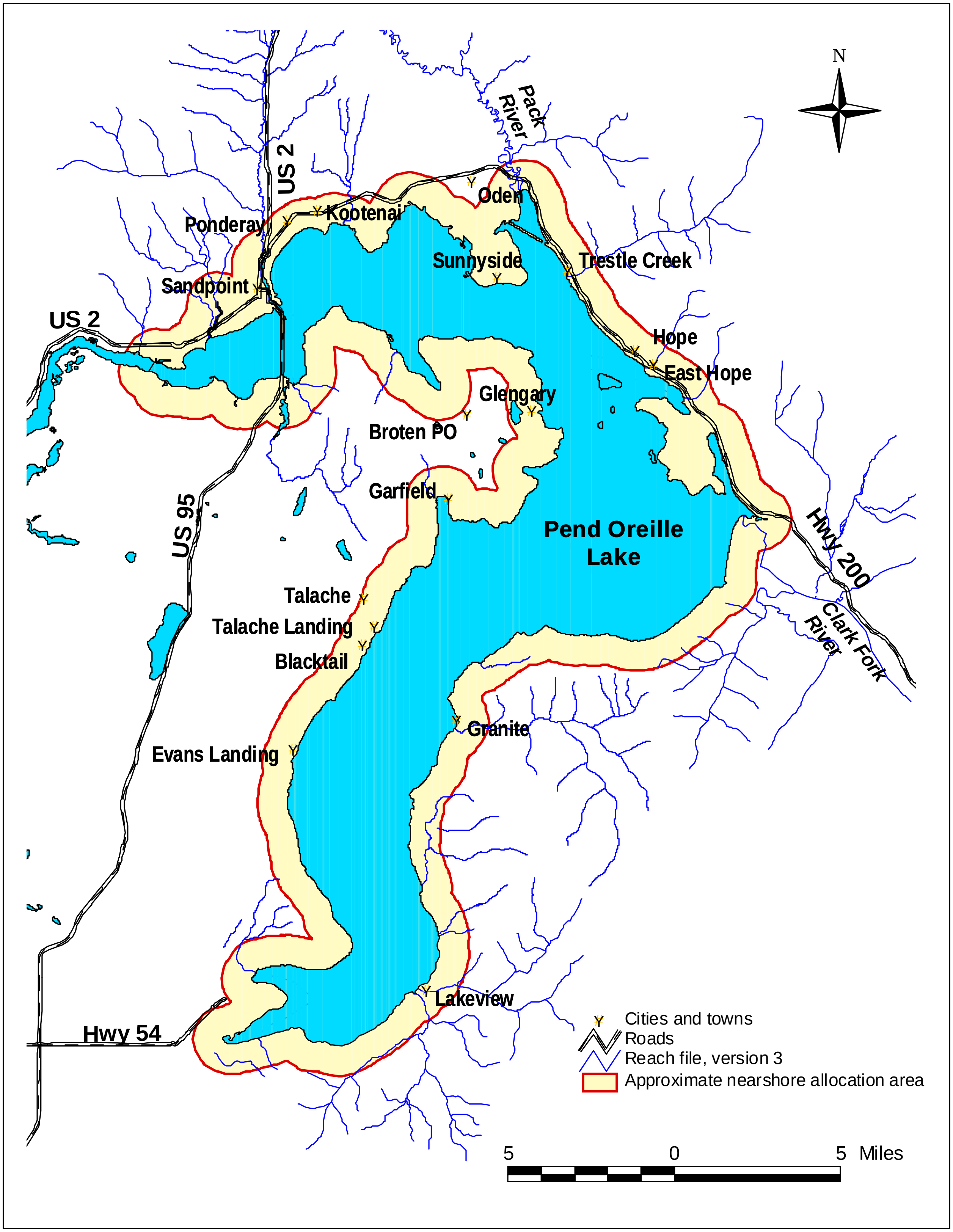

Figure 4. Approximate area corresponding to the nearshore allocation area

Seasonal Variation

The Pend Oreille Lake Nearshore Nutrient TMDL is a seasonal limit aimed at protecting water quality during the critical summer months, when the lake is most vulnerable to the impact of excessive nutrient loading. Because the TMDL analysis and the calculation of the loading capacity are based on data collected during summer months, the TMDL is inherently representative of summer conditions.

6. Public Participation

The nutrient TMDL for the nearshore waters of Pend Oreille Lake was available for public comment from February 19, 2002, through March 19, 2002, and a public meeting was held to present and discuss the draft TMDL on February 28, 2002, in Sandpoint, Idaho. The draft TMDL document was posted on the TSWQC and IDEQ websites and was available from IDEQ's Coeur d'Alene Regional Office, the Sandpoint Library, and TSWQC's office in Sandpoint. The public meeting and public comment period were advertised in the local newspaper, Bonner County Daily Bee, and two press releases about the public comment period and meeting were also submitted to the Bonner County Daily Bee, Spokesman-Review, River Journal, Priest River Times, Sandpoint Newsline and KPND Radio. In addition, an informational flyer on the public comment period and public meeting was sent to the TSWQC's mailing list of 200 people.

Thirty-one people attended the public meeting and written comments on the TMDL were received from five people. Responses to comments received at the public meeting and throughout the comment period are included in Appendix E.

7. Implementation

IDEQ will develop a separate Implementation Plan associated with the Pend Oreille Lake Nearshore Nutrient TMDL within 18 months of the TMDL approval. The implementation plan will contain details on the TMDL implementation schedule and activities. Potential management actions used to implement this TMDL are contained in Table 6, which lists the management actions identified by the USEPA (1993) study as options for reducing nutrient loading to protect the nearshore waters of Pend Oreille Lake.

Education should be considered as an addition to the implementation activities listed above. Watershed education should include informing the public and development community about the fish and other wildlife that depend on good water quality, the causes of pollution, and the environmental safeguards in place to maintain and restore water quality. In particular, the community needs to understand the effects of land-disturbing activities and other sources of pollution on the water quality of their lake and to be aware of the local ordinances and other regulations in place to prevent degradation of the aquatic resources.

The TSWQC considers education one of the most effective methods of reducing the nutrient loading to waterways in the Clark Fork-Pend Oreille Basin. Informed watershed and lake users will be more conscious of how their activities affect the body of water they depend on and value, and thus will be more willing to modify those activities to meet water quality goals they understand.

Individual state plans and the basin management plan strongly emphasize public education. A comprehensive and well-targeted public education program should have three components:

1. Inform watershed users how their activities directly affect the body of water they depend on and value. The TSWQC views distribution of this message as one of the most effective methods of reducing the amount of nutrients that enter the water.

2. Clearly articulate water quality goals and the benefits of improving and protecting water quality. Users and residents may be more willing to modify their activities to meet water quality goals that they understand.

3. Educate the public about the benefits of any management action that is selected for implementation as a means of building public support for the action.

Table 6. Nonpoint source controls intended to reduce nearshore eutrophication in Pend Oreille Lake by reducing nutrient loading from local sources (based on USEPA, 1993, pg 45)

Management Action	Lead Agency[a]	Priority	Cost (dollars)	Funding Source(s)
EDUCATION				
Prepare brochures to support recommended ordinances and provide a clearinghouse for information for interested and concerned lake and watershed users.	Tri-State Council	High	60,000 annually	CWA Section 525 Reauthorization, CWA Section 314 (Clean Lakes) Program, National Environmental Education Act
SEPTIC SYSTEMS				
Install centralized sewage treatment systems in developed areas.	IDEQ, PHD, Local Sewer Districts	High	Cost depends on site	CWA Section 525 Reauthorization, State Revolving Fund, Municipal Facilities Construction Grants Program
Identify areas and zone for more dense development with centralized sewage treatment systems.	Bonner County, PHD, NRCS	High	Unknown (low)	Bonner County, ID
Perform periodic mandatory maintenance and operation inspections of septic systems.	PHD, Local Sewer Districts	Medium	25,000 annually	Private Landowner
STORM WATER				
Implement a county storm water management plan.	Bonner County, PHD, IDEQ	High	15,000 (development only)	Clean Water Act Section 525 Reauthorization, Clean Water Act Section 314 (Clean Lakes Program), Private Landowner, Bonner County
FERTILIZER USE				
Implement a county ordinance prohibiting the sale of phosphate lawn fertilizers.	Bonner County, IDEQ	Medium	2,000 (development only)	Clean Water Act Section 525 Reauthorization, Clean Water Act Section 314 (Clean Lakes Program),Bonner County
Develop best management practices (BMPs) for methods and rates of application of fertilizers based on soil type and slope.	Bonner County, NRCS	Medium	10,000	CWA Section 525 Reauthorization, CWA 314 (Clean Lakes) Program, CWA Section 319 (Nonpoint Source) Program
Implement a county ordinance requiring fertilizer BMPs within a lake or stream protection zone.	Bonner County	Medium	2,000 (development only)	CWA Section 314 (Clean Lakes) Program, Bonner County

Management Action	Lead Agency[a]	Priority	Cost (dollars)	Funding Source(s)
DEVELOPMENT AND CONSTRUCTION				
Implement a county erosion control plan.	Bonner County, IDEQ	High	15,000 (development only)	CWA Section 525 Reauthorization, CWA Section 314 (Clean Lakes Program), CWA Section 319 (Nonpoint Source) Program
Amend zoning ordinances to set residential density based on land and lake capabilities.	Bonner County, NRCS, IDEQ	High	Unknown (Low)	Bonner County
Amend zoning ordinances to restrict development in environmentally sensitive and unstable areas.	Bonner County, NRCS	Medium	Unknown (Low)	Bonner County
Increase setbacks between development and watercourses.	Bonner County, IDEQ	Medium	Unknown	Bonner County
Allow individuals and developers to design erosion control plans based on soil type and slope.	Bonner County, IDEQ	Medium	30,000 annually	Bonner County, Private Landowner
ROAD CONSTRUCTION				
Implement road construction and maintenance BMPs specific to Pend Oreille Lake watershed and develop a Memorandum of Understanding with Bonner County Road Department.	Bonner County, IDEQ	High	10,000 (development only)	CWA Section 525 Reauthorization, CWA Section 314 (Clean Lakes) Program, CWA Section 319 (Nonpoint Source) Program
Review travel corridor construction proposals within the Pend Oreille Lake watershed.	IDEQ, ITD	High	N.A.	CWA Section 106 Funds
AGRICULTURE				
Identify and control sources of nutrients in Pack River and Sand Creek.	IDEQ, SWCD	High	30,000 (identification only)	CWA Section 525 Reauthorization, CWA Section 314 (Clean Lakes) Program, Agricultural Water Quality Management Program
FORESTRY				
Implement a cooperative road management program with federal, state, and private landowners.	IDL	High	Unknown	CWA Section 319 (Nonpoint Source) Program
Increase personnel for enforcement of the Forest Practices Act and operator training.	IDL	Medium	60,000 annually per new hire	Unknown
Encourage nomination of stream segments of concern to develop site-specific BMPs.		Medium	N.A.	Idaho Antidegradation Policy
MOTORIZED WATERCRAFT USE				
Require marinas to install pump-out stations.	Bonner County	High	Unknown	Private Landowner
Enforce the new sewage discharge standard.	County Marine Divisions	High	N.A.	Unknown

Management Action	Lead Agency[a]	Priority	Cost (dollars)	Funding Source(s)
Implement a ban on use of phosphate detergents to clean watercraft.	Bonner County, IDEQ	High	1,000 (development only)	CWA Section 525 Reauthorization, CWA Section 314 (Clean Lakes) Program, Bonner County
SHORELINE BURNING				
Implement a county ordinance prohibiting shoreline burning	Bonner County, IDL	Medium	2,000 (development only)	CWA Section 525 Reauthorization, CWA Section 314 (Clean Lakes), Bonner County
AQUATIC MACROPHYTES				
Selective removal of aquatic plants by hand	Bonner County	Low	100-1,500 for hand-held cutter	Bonner County
Remove aquatic plants periodically using mechanical harvesting	Bonner County	Low	500-800 per acre biannually	Bonner County
Cover lake bottom with fabric barrier	Bonner County	Low	0.06-1.25 per ft^2 with annual maintenance	Bonner County
ENVIRONMENTALLY SENSTIVE OR CRITICAL AREAS				
Map environmentally sensitive areas with high water tables (wetlands)	USACE, NRCS	Medium	1,000	CWA Section 525 Reauthorization, Bonner County
Purchase or dedicate environmentally sensitive or critical areas		Low	Unknown	Habitat Improvement Program (Idaho), Forest Stewardship Program, Bonner County, Private Landowner

[a]Agencies: IDEQ = Idaho Department of Environmental Quality; IDL = Idaho Department of Lands; ITD = Idaho Transportation Department; NRCS = Natural Resources Conservation Service; PHD = Panhandle Health District; SWCD = Soil and Water Conservation District; USACE = U.S. Army Corps of Engineers

8. Monitoring

The impacts of nutrients on designated uses are difficult to characterize in Pend Oreille Lake. For this reason, this TMDL is likely to have uncertainty associated with selection of numeric targets representative of the desired nearshore lake condition. Recognizing this inherent uncertainty, EPA has encouraged the development of TMDLs using available information and data with the expectation that a commitment to additional monitoring will accompany the TMDL (USEPA, 1991). This approach allows proceeding with source controls while additional monitoring data are collected to provide a basis for reviewing the success of the TMDL. This approach enables stakeholders to move forward with resource protection based on existing data and less rigorous analysis.

A monitoring plan for the nearshore waters of Pend Oreille Lake will be included in the implementation plan developed for the TMDL. The key needs of follow-up monitoring for the nearshore of Pend Oreille Lake are to assess the water quality target and action threshold and to evaluate the link between total phosphorus and algae growth and visible aesthetic impairment. Recommendations for future monitoring include the following:

- Continue periodic monitoring at nearshore sites established in Falter et al. (1992), including analysis for chlorophyll a, total phosphorus, Secchi depth, and total nitrogen.

- Survey the extent or number of sites that are experiencing nuisance algae growth (through aerial photography surveys).

- Conduct periodic updates of land use distribution (coordinated with implementation efforts) to identify any links between land use activities and nearshore condition.

The monitoring plan also will identify guidelines for using the TMDL targets to evaluate water quality and the attainment of water quality standards in the nearshore waters. The guidelines for using the targets will incorporate instantaneous and short-term scenarios similar to those established in the Montana and Idaho Border Nutrient Agreement technical guidance document (TSWQC, 2001) for the open waters of Pend Oreille Lake. TSWQC (2001) defines an instantaneous exceedance as any exceedance of the TMDL action threshold (12 µg/L). A short-term exceedance is defined as 2 consecutive years of TMDL action threshold exceedances in the same location. Instantaneous exceedances will likely result in

- Review of the data to ensure confidence.

- Review of factors such as, but not limited to, annual runoff/water yield, average temperature, number of sunlight days.

- Identification of causes

- Determination of error factor.

- Written summary of findings.

Short-term exceedances will result in

- Review of data to ensure scientific evidence of a change in trend
- Review of causes and sources
- Revision of TMDL implementation plan and management strategy
- Written report of findings and recommendations

Any future monitoring in Pend Oreille Lake should build on and be coordinated with current monitoring activities in the watershed. Appendix F summarizes existing monitoring efforts conducted by TSWQC in the larger Clark Fork-Pend Oreille Lake-Pend Oreille River watershed.

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Appendix A. Black-and-White Figures

This appendix contains black-and-white reproductions of the maps in the main body of this document.

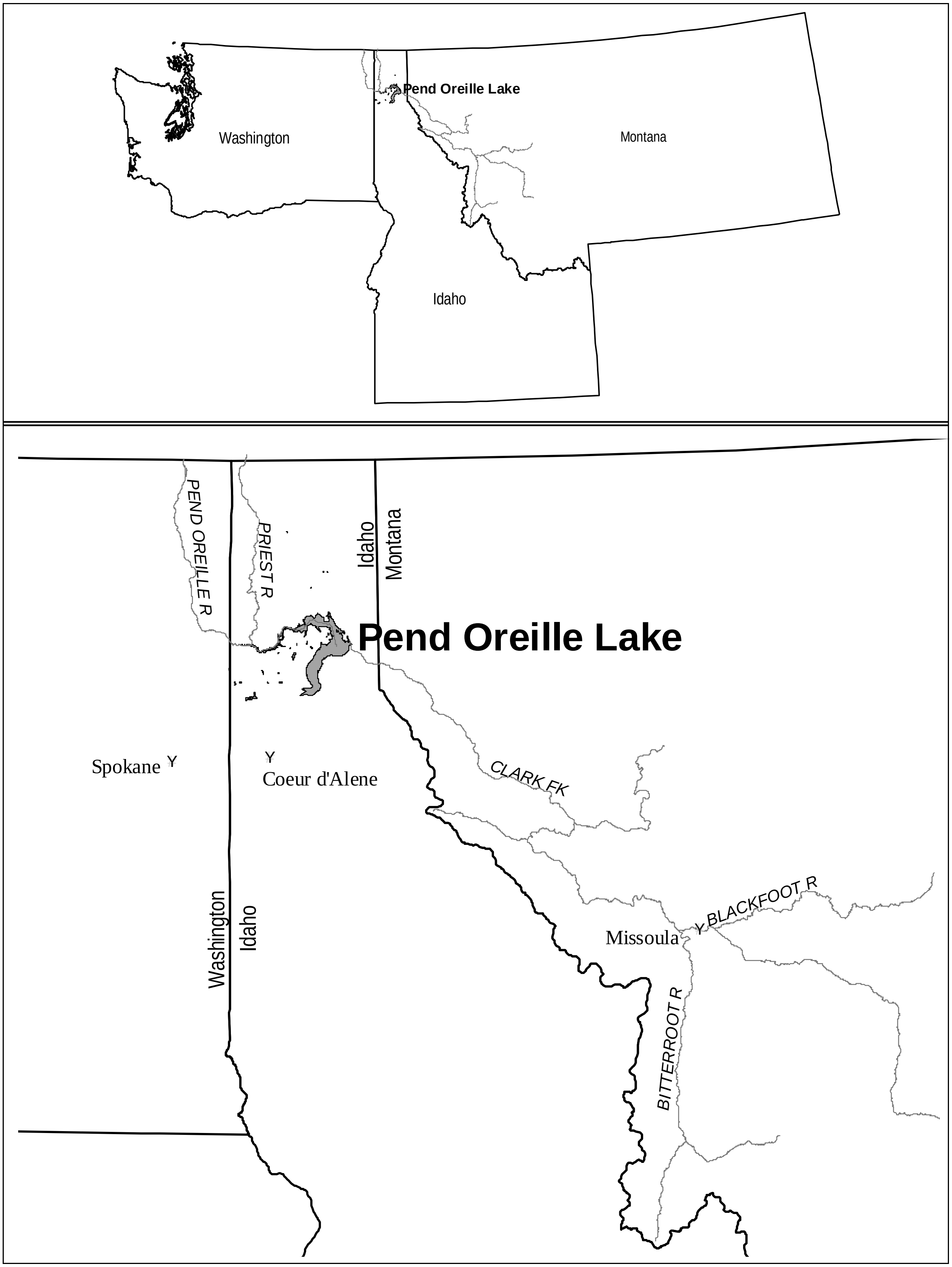

Figure A-1. Regional location of Pend Oreille Lake

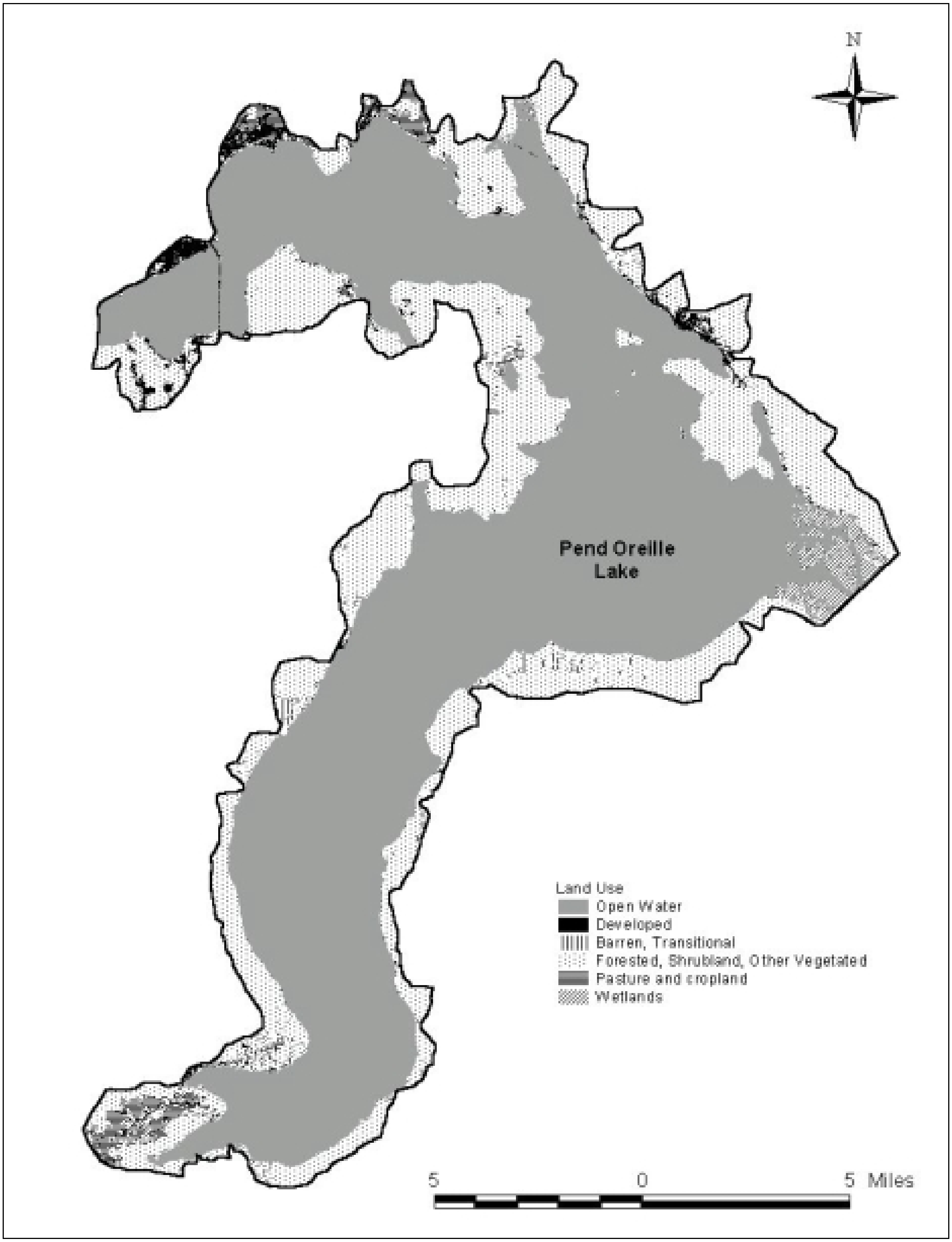

Figure A-2. Land use of nearshore drainage area

Figure A-3. Location of nearshore sites used in TMDL analysis

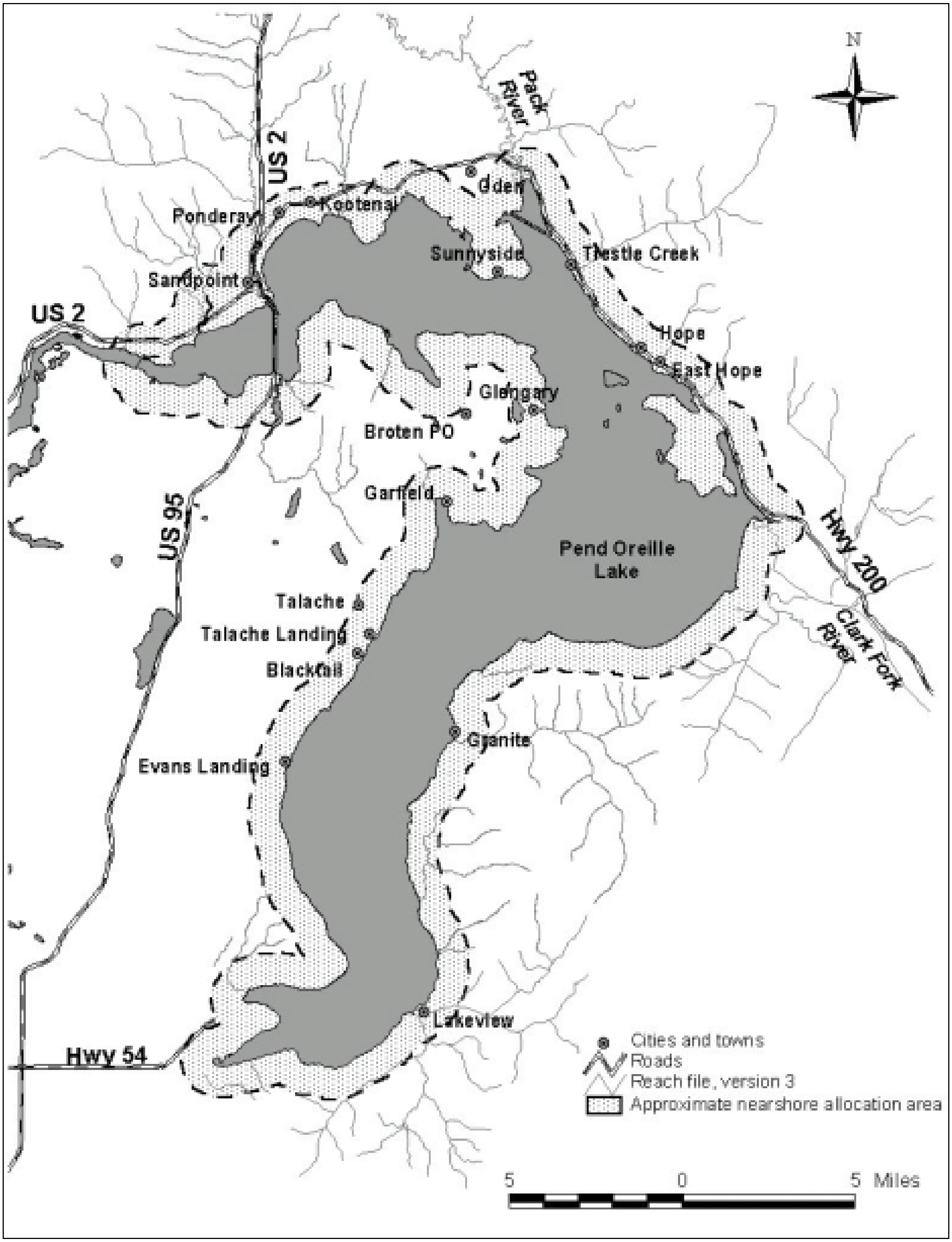

Figure A-4. Approximate area corresponding to the nearshore allocation area

Appendix B: Supporting Information on Phosphorus Targets

The TMDL targets established for the Pend Oreille Lake nearshore TMDL are comparable to other values included in literature as representing conditions not impaired by eutrophication as well as targets used in other nutrient-related TMDLs. The following sections include supporting information on literature values typically used to represent desired lake conditions and on lake targets used in other phosphorus TMDLs. It is important to note that although the Pend Oreille Lake nearshore targets are within range of typical literature values and previously used TMDL targets, the Pend Oreille Lake TMDL is highly unique in its scope. This TMDL focuses only on the nearshore waters, an area that typically has different dynamics and conditions than open waters of a lake. Therefore, the information in this section, while useful in providing background on and examples of phosphorus water quality targets, is not directly applicable to the nearshore waters of Pend Oreille Lake. These targets and TMDL information are provided to put the Pend Oreille Lake targets in a larger context and provide a qualitative frame of reference for targets used in TMDLs to represent desired water quality conditions.

Trophic Status

Eutrophication represents the natural aging process of a lake during which it evolves into a bog or marsh and eventually turns to dry land. Human activities and the associated nutrient pollution can accelerate the eutrophication process, resulting in accelerated biological productivity and undesirable accumulation of algal growth. The extent of eutrophication in a lake is classified their trophic state, representing their availability of nutrients. Oligotrophic describes a waterbody with low nutrient levels, accompanied by low productivity and algal growth and high transparency. Eutrophic waters experience increased biological productivity, high nutrient levels and excessive algal growth. Mesotrophic is the intermediate classification between eutrophic and oligotrophic, when nutrient levels and the associated problems are beginning to increase and move toward eutrophic conditions.

There are characteristics of a lake that can be evaluated to classify their trophic state, including concentrations of nutrients and chlorophyll *a* and measures of secchi depths. Pend Oreille Lake's nearshore TMDL target for phosphorus (9 µg/L) is consistent with values associated with oligotrophic waters. The following are the widely accepted ranges representing the different trophic states:

Oligotrophic	<10 µg/L
Mesotrophic	10-20 µg/L
Eutrophic	>40 µg/L

References include Chapra (1997), Novotny and Olem (1994), USEPA (1974), USEPA (1999), and Vollenweider (1968).

However, it is important to note that using site-specific data is preferable to using literature values as water quality targets, to capture any site-specific conditions or trends.

Example Phosphorus Targets

This section provides examples of total phosphorus targets used in other TMDLs to represent water quality conditions that support designated uses. It is important to note that all lakes vary and the development of a TMDL target should be based on site-specific data and conditions, where possible. Additionally, these examples are targets applied to entire lakes or specifically the open waters of a lake, unlike the Pend Oreille Lake targets that apply only to the nearshore areas.

Many TMDLs set specific concentrations of nutrient or related parameters as TMDL targets, many times reflecting the characteristics of the desired trophic status of a lake. The following are examples of water quality targets established for phosphorus.

Trophic Status Index. Numerous TMDLs for lakes throughout the nation establish water quality targets based on trophic status. For example, many TMDLs set total phosphorus targets, as well as secchi depth and/or chlorophyll *a* targets, at levels that represent oligotrophic or mesotrophic conditions. For example, South Dakota and West Virginia uses Trophic Status Index (TSI) as a 303(d) listing parameter and develops TMDLs to result in TSI values within acceptable ranges. This provides a system that is consistent among state water quality standards, listing guidance and local studies. The following are TSI ranges that reflect different trophic states (USEPA, 1999; Novotny and Olem, 1994):

TSI < 40	most oligotrophic
35 > TSI >40	mesotrophic
TSI > 45	eutrophic

The TSI (total phosphorus) corresponding to the Pend Oreille Lake nearshore TMDL target (9 µg/L) is 35, representing oligotrophic conditions.

Recommended Nutrient Criteria. USEPA has developed guidance for assisting states and tribes in establishing numeric nutrient water quality standards (USEPA, 2000a), as well as developed supporting documents with recommended criteria for defined ecoregions throughout the country. EPA recommends that, wherever possible, states develop nutrient criteria that fully-reflect localized conditions (USEPA, 2000b). However, the guidance provides an option for developing criteria as well as provides recommended criteria for states to adopt in lieu of developing site-specific criteria. The documents describe a method for identifying appropriate nutrient criteria for lakes and reservoirs based on data collected from lakes within an ecoregion. Within each ecoregion, reference lakes are identified to represent the least culturally impacted waters. Monitoring data from these lakes are then used to identify recommended nutrient criteria. The criterion for a particular parameter (e.g., phosphorus) is calculated as the 75^{th} percentile of the values measured in the reference lakes. However, if there are no reference lakes with available data in the ecoregion, the recommended criterion is calculated as the 25^{th} percentile of data from all of the monitored lakes in the ecoregion. These values approximate one another and are assumed to represent minimally impacted conditions and be protective of designated uses. Pend Oreille Lake is located in Nutrient Ecoregion II (Western Forested Mountains), for which there is no reference lakes identified. The recommended nutrient criterion for total phosphorus in this ecoregion is based on data from all lakes with available monitoring data and is 8.75 µg/L (USEPA, 2000b).

Lake Champlain, Vermont (VDEC, 2001;USEPA, 2000). Vermont established site-specific water quality criteria for phosphorus in Lake Champlain, based in part on the results of an analysis of user surveys completed as part of a volunteer monitoring program. From 1987 to 1991, volunteers completed surveys about the lake's aesthetics and suitability for recreational uses at the time of water quality sample collection. Vermont established criteria for eutrophication-related parameters based on the relationship between the parameter and citizen perceptions of the lake. A mean phosphorus concentration of 14 µg/L was established to protect recreational use and enjoyment of the lake. This criterion is applied as a seasonal or annual mean and represents a value at which algal nuisance conditions would occur only 1 percent of the time during the summer. In June 2001 Vermont Department of Environmental Conservation released a draft of the Lake Champlain Phosphorus TMDL for public comment. The TMDL establishes several loading scenarios to meet the phosphorus water quality criteria.

Lake Chelan, Washington (USEPA, 1994). In 1991, a phosphorus TMDL was developed for Lake Chelan, WA. Lake Chelan is a highly valuable natural resource to the area and was classified as ultra-oligotrophic. Although not listed on the state's 303(d) list as impaired, increasing development created concerns about maintaining the lake's high water quality. A water quality assessment and subsequent TMDL were established to establish limits for nutrient loading to the lake to maintain the lake's ultra-oligotrophic condition. The development of the TMDL target was based on the accepted characteristics of trophic status. A phosphorus target of 4.5 µg/L was established and represents the generally accepted value for the ultra-oligotrophic classification.

Utah State Water Quality Standards. Utah water quality standards establish a 25µg/L criterion for phosphorus in lakes and reservoirs. Any phosphorus TMDLs developed for lakes in the state must establish load allocations to result in the phosphorus criterion.

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Appendix C. Technical Analysis: Calculating the Pend Oreille Lake Nearshore Nutrient TMDL

The approach for establishing the nutrient TMDL for the nearshore waters of Pend Oreille Lake was developed to use existing water quality and physical data for the nearshore area and to work within the current management goals for the larger Pend Oreille Lake watershed, with a focus on nearshore sources and conditions. With these goals as underlying guidelines, a simple mass balance approach was chosen to evaluate water quality conditions in the nearshore waters. Using representative “cells” of water along the nearshore, mass balance equations were used to estimate TMDL loading capacities for the individual cells, which were then evaluated to determine an average TMDL for the entire nearshore area of the lake.

The following sections discuss the mass balance approach for determining the nutrient TMDL for the nearshore waters of Pend Oreille Lake, including:

- Summary of data available for the nearshore analysis.
- Identification of water quality targets used in the analysis.
- Identification of areas for analysis of nearshore conditions
- Loading analysis to identify the TMDL for the nearshore waters.

Summary of Available Nearshore Data

Falter et al. (1992) provides the only available nutrient data for nearshore areas in the lake. The study presented data collected in 1989 and 1990 at 17 sites within the nearshore area. Water samples were analyzed for nutrient and bacteria parameters. Physical limnological measurements and attached algae measurements were also reported for the sampling sites and events. The nearshore data contained in Falter et al. (1992) were used to parameterize the mass balance equations and determine several of the major input characteristics. More detail on the specific uses of the data in the TMDL analysis is included throughout the following sections describing the analysis. Table C-1 presents a summary of data available in the Falter et al. (1992) report.

Water Quality Targets

Maintaining in-lake water quality and reducing the potential for nearshore eutrophication are the water quality goals for Pend Oreille Lake. These goals are intended to maintain the water quality standards applicable to the lake and to protect and preserve the beneficial water uses of the lake by controlling pollutants, specifically phosphorus, that enter the lake from nearshore sources. However, because the applicable water quality standards are narrative in nature, it is necessary to identify a numeric water quality target for the TMDL. The numeric target represents a measurable endpoint that is equivalent to attainment of the narrative water quality standard.

Nitrogen and phosphorus contribute to algae growth, and either can be limiting depending on their ratio. Past studies indicate that phosphorus most often limits algae and aquatic plant growth in Pend Oreille Lake, with phosphorus being the primary or exclusive limiting nutrient for algae growth at sites sampled. It is difficult to conclusively identify the threshold concentration of nutrients that causes visible slime growth and other nuisance aquatic growths. For the Pend Oreille nearshore TMDL, the data collected for Falter et al. (1992) were evaluated to identify an appropriate target phosphorus concentration for the nearshore waters.

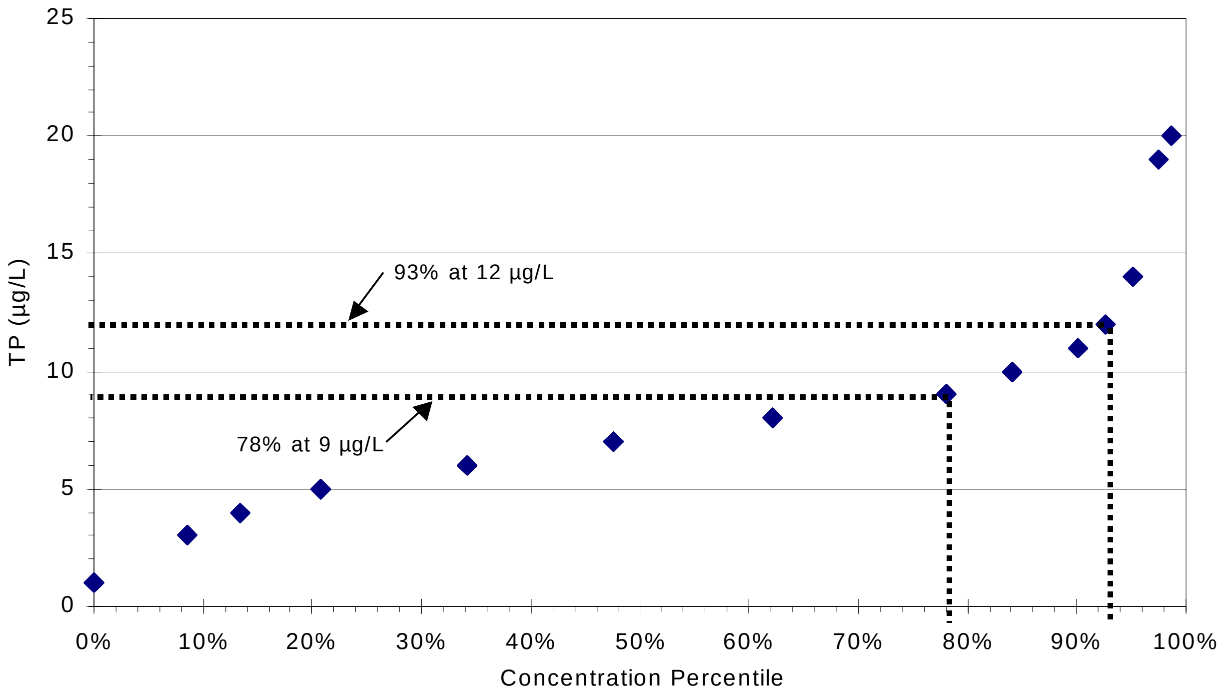
Table C-1. Summary of nearshore data collected for Falter et al. (1992)

Lake Section	Site	Development Status[a]	1989 Mean TP (µg/L)	1990 Mean TP (µg/L)	2-Year Mean (µg/L)
North	Springy	D	10	10	10
North	Rocky	D	9	5	7
North	Kootenai	D	17	8	12
North	Sunnyside	U	9	8	8
North	Bottle Bay	M	6	5	6
North	Oden	D	9	8	9
North	Trestle	D	12	8	10
Mid	Ellisport Bay	D	8	6	7
Mid	Warren Island	U	9	5	7
Mid	Camp Bay	M	8	5	6
Mid	Garfield	D	7	4	5
Mid	Granite	U	7	2	5
Mid	Talache	U	7	5	6
South	Lakeview	U	7	3	5
South	Cape Horn	M	6	3	4
South	Bayview	D	6	3	5
South	Navy	M	-	4	4

[a]D = developed; U = undeveloped; M = moderately developed.

Falter et al. (1992) collected total phosphorus and periphyton samples at 17 nearshore locations for critical summer periods in 1989 and 1990. No correlation could be found between total phosphorus (µg/L) and density of periphyton growth. An analysis of the data suggests that this lack of correlation may be due to infrequent total phosphorus sampling (once per month) or differences in parameter measurements: total phosphorus samples represent grab samples at a certain time and location, whereas periphyton measurements represent the amount of growth per area over a roughly 30-day period.

Because no correlation between algal and phosphorus data could be established, phosphorus data was evaluated independently to identify any trends or distributions in the data. Review of the total phosphorus data revealed a noticeable trend in the levels observed in the nearshore waters. If the total phosphorus concentrations are ranked in order of occurrence, the majority of sampling stations were observed to have a concentration less than or equal to 9 to 20 µg/L. Figure C-1 depicts each total phosphorus level (vertical axis) versus its associated percentile (horizontal axis). (The percentile represents the percentage of observed values that are less than or equal to each designated total phosphorus level.) Evaluating the graph shows that obvious inflection points occur in the plot where an increase in percentile (or occurrence) requires a significant increase in the total phosphorus level observed. The first point occurs at the 78th percentile, where the slope increases substantially and suggests that a much higher total phosphorus level is required to ensure that percentiles higher than 78 are obtained. A second inflection occurs at the 93rd percentile. Total phosphorus levels at the 78th and 93rd percentiles are 9 µg/L and 12 µg/L, respectively. To obtain higher percentiles of observed data, significant relative increases in the total phosphorus level are required.



Note: The percentile of a concentration represents the percentage of all the concentrations in the record that are equal to or less than that concentration.

Figure C-1. Distribution of the occurrence of observed total phosphorus concentrations

It is assumed that these values represent thresholds at which a noticeable change in water quality conditions occurs in the nearshore waters. Therefore, the TMDL target is established as 9 µg/L total phosphorus. A secondary target of 12 µg/L is established to assist in monitoring the nearshore conditions. The primary target of 9 µg/L represents an average concentration throughout the nearshore waters, while the secondary target of 12 µg/L represents an instantaneous concentration used to evaluate isolated conditions represented by grab samples collected during routine monitoring. Development of future monitoring guidelines for the nearshore waters of Pend Oreille Lake will establish certain frequency and percent exceedance criteria for this target. Essentially, the guidelines will establish criteria that indicate when the water quality in the nearshore waters is consistently violating water quality goals rather than experiencing infrequent, temporary spikes in concentration. The secondary target is established as a guideline for gauging when nutrient controls are necessary to maintain acceptable water quality within the nearshore waters.

Identification of Nearshore Analysis Sites

Several representative nearshore areas (“cells”) and their loading and water quality conditions were examined under a conservative set of assumptions to identify the loading capacity of the entire nearshore area of Pend Oreille Lake. These cells are assumed to appropriately represent typical conditions occurring in the nearshore area. The individual loading conditions and loading capacities for these cells can be extrapolated to identify a broader loading limit for the nearshore area.

Sites available for the development of the nearshore cells are the sampling sites from the Falter et al. (1992) study. Appropriate sites to be used in developing the representative cells were selected for the analysis based on the following information:

- *Availability of water quality data.* The development of the mass balance equations to appropriately represent and simulate behavior of the nearshore cells is dependent on the availability of data to characterize conditions. Therefore, the sites evaluated for use in the nearshore TMDL analysis were the 16 sampling locations analyzed in Falter et al. (1992) study. Further criteria were used to select a subset of the sampling sites for use in the TMDL analysis.
- *Location of sites within the lake (e.g., north, south).* The TMDL is written to represent average loading limits for the entire nearshore area of the lake. However, because there are hydrologic differences among nearshore areas, there is some variation in loading and water quality characteristics. Selecting a set of sites that reflect different regions of the lake's nearshore allows the loading analysis to capture any variability in the lake.

- *Extent and depth of nearshore waters.* It is important for the site to have relatively shallow nearshore depths to appropriately define the cell and characterize the volume and area. At some of the nearshore sites, the nearshore area did not extend far from the shoreline, resulting in a relatively small volume and surface area that was difficult to characterize.

- *Land use of watershed draining to the site.* Because the land use around the lake varies, sites representing developed and undeveloped drainage areas were used in the analysis to capture any variability in land use and resulting loading.

- *Location of the sites relative to significant tributary inflow*. The conditions of a site in close proximity to a major tributary could be largely influenced by the tributary inflows; the characteristics and flow of the cell near a major tributary would likely not be appropriately represented by the set of assumptions underlying the mass balance approach. The assumptions are designed to represent the behavior of nearshore cells that receive all or the majority of their inflows from direct runoff from the land immediately surrounding the lake. Therefore, sites located near tributary inflows were eliminated from consideration in the analysis.

Based on these criteria, six sites were selected for development of nearshore cells for use in the TMDL analysis. Table C-2 lists and provides characteristics of the six sites, and Figure C-2 presents their location.

Table C-2. Characteristics of nearshore analysis sites

Nearshore site	Location[a]	Drainage area (ha)[a]	Max. TP (µg/L)[a]	Avg. Secchi depth (m)[a]	Development status[a]	Land uses
Oden	North	2,036	11	2.98	Developed	Commercial/industrial, residential, pasture, shrubland, forest
Sunnyside[b]	North	412	11	6.14	Undeveloped	Pasture, shrubland
Garfield	Middle	1,874	7	7.75	Developed	Residential, grasslands, pasture, forest
Talache Landing	Middle	2,085	9	7.68	Undeveloped	Shrubland, grassland, forest, pasture, transitional
Bayview	South	2,084	7	8.95	Developed	Residential, forest, grassland, pasture, transitional
Lakeview	South	557	8	9.0	Undeveloped	Forest, transitional, pasture, shrubland

[a] Based on information contained in Falter et al. (1992).
[b] Sunnyside was later removed from the analysis because of inconclusive estimation of the flow across the cell-lake boundary. The mass balance equation produced a negative flow across the boundary, indicating that the behavior of the site is irregular and is not appropriately captured in the mass balance assumptions.

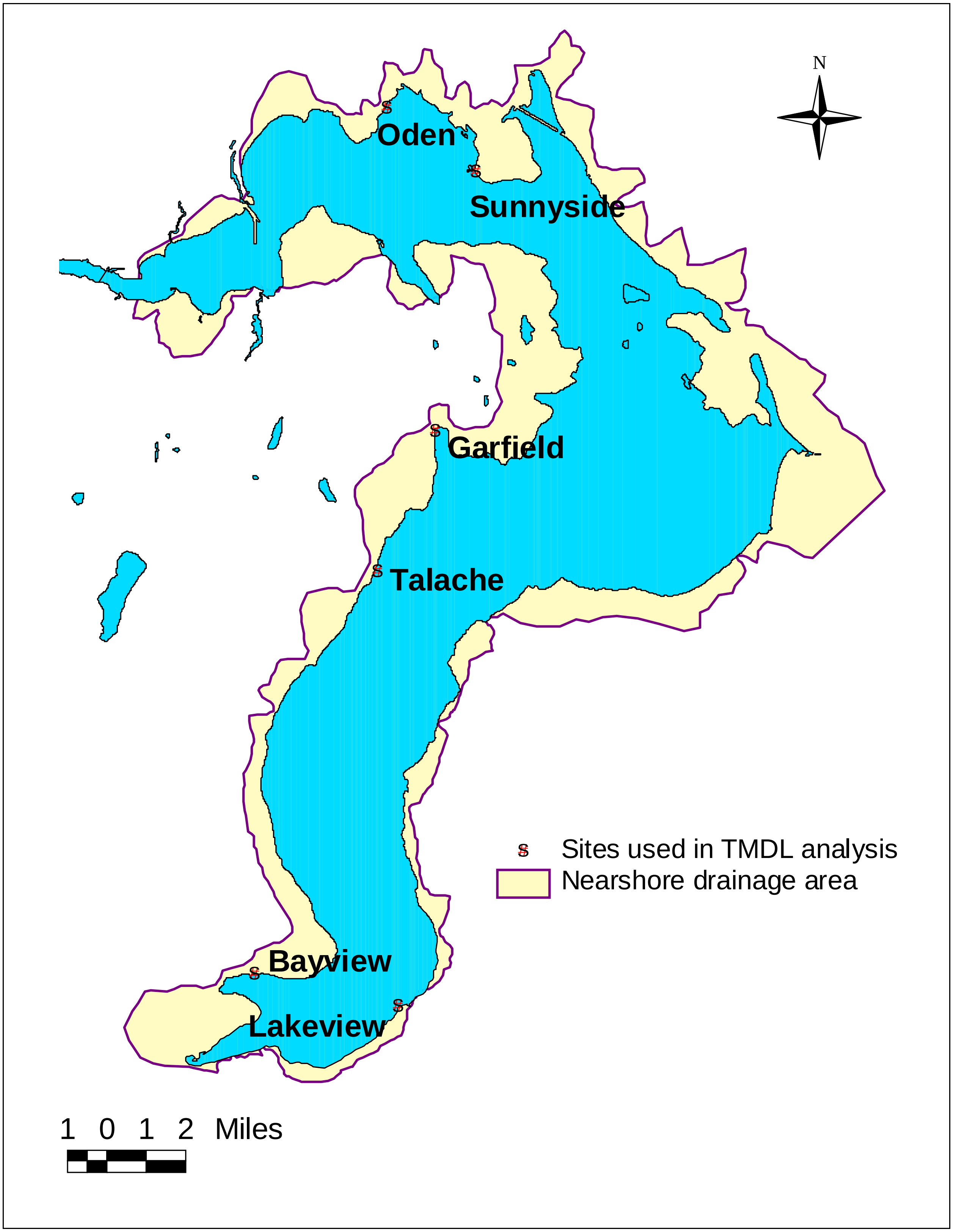


Figure C-2. Location of nearshore sites used in TMDL analysis

Loading Analysis

The following sections discuss the approach used to evaluate the nearshore cells and calculate the loading capacities for the cells, including discussion of the underlying assumptions for the analysis.

Analysis Assumptions

Mass balance equations were used to represent loading and flow conditions in the nearshore cells for the purpose of calculating associated loading capacities. To complete the analysis, certain assumptions were established concerning behavior of the cells and their impairment. The following are the underlying assumptions associated with the mass balance analysis for the nearshore cells in Pend Oreille Lake:

- *Nearshore waters are phosphorus-limited.* Several past studies indicate that phosphorus is the limiting nutrient for algae growth in Pend Oreille Lake. Therefore, the target concentration is expressed as an in-lake phosphorus concentration. Specifically, the target is a total phosphorus concentration, to be consistent with the available data for the nearshore sites.

- *Only net flow is considered in the mass balance.* Mixing across the lake-nearshore boundary is considered; however, it is assumed that flow goes only from the nearshore cell into the open lake.

- *Problematic algae occur as attached bottom algae.* Concern over the quality of nearshore waters is driven by the potential occurrence of attached algae and slimy growths on rocks. Therefore, it is assumed that the impairment in the nearshore waters manifests as attached bottom algae as opposed to suspended algae.

- *Nearshore volume is limited to the littoral zone.* Because it is assumed the potential impairment to the nearshore waters will be as attached bottom algae, the critical areas are within the littoral zone of the lake. The littoral zone is the band of water along the shoreline where light can penetrate to the bottom. Therefore, the volumes of the nearshore cells are controlled by the depth of light penetration (as measured by a Secchi disk).

- *Nearshore volumes are completely mixed.* It is assumed that the volumes of the nearshore cells are completely mixed. Therefore, the observed phosphorus concentration from grab samples is considered representative of the concentration throughout the cell.

Mass Balance Analysis

A mass balance equation representing steady-state conditions was applied to each nearshore cell to calculate the loading capacity for each cell. Those loading capacities were then used to identify a loading capacity for the entire nearshore area of Pend Oreille Lake.

The equation simulates behavior in the cell using various parameters representing the cell's characteristics, both physically and chemically. The following defines the mass balance equation that was applied to each cell:

$$V\frac{dC}{dt} = Load_{in} - QC - kVC - vA_sC$$

$$\text{At steady state, } V\frac{dC}{dt} = 0$$

$$\begin{aligned}
&\text{Load}_{in} = \text{runoff} + \text{septic/groundwater} \\
&\text{Q} = \text{flow across cell boundary} \\
&\text{k} = \text{first} - \text{order loss coefficient} \\
&\text{V} = \text{volume of nearshore cell} \\
&\text{v} = \text{settling velocity} \\
&\text{A}_s = \text{surface area of nearshore cell} \\
&\text{C} = \text{concentration in nearshore cell}
\end{aligned}$$

In the equation, some input parameters are constant for each cell throughout the analysis and are defined based on site-specific information about the cells, whereas some parameters in the equation vary through the different steps of the analysis. Table C-3 provides brief descriptions of the constant and variable parameters included in the analysis. (Flow across the cell boundary [Q] is also a constant parameter. However, it is unknown and must be identified before the loading capacities can be calculated. The first step of the analysis identifies the value for Q.)

The following discussion presents the steps used to identify the loading capacity for each of the cells, and, in turn, of the nearshore waters of Pend Oreille Lake. The discussion of the mass balance loading analysis is organized according to the two primary steps in the analysis:

1. Evaluate existing conditions
2. Calculate loading capacity

Table C-3. Constants used in mass balance analysis of nearshore cells

Parameter	Definition	Source
Constant parameters		
Q	Flow across cell boundary	Determined using observed data in the mass balance equation
k	First-order loss coefficient	(0.001 day^{-1}) x (observed chlorophyll *a* concentration at cell site)
V	Volume of cell	Estimated using observed Secchi depths, USGS topographic maps, and bathymetric map of lake
v	Settling velocity of total phosphorus	10 cm/day (Cerco and Cole, 1994)
A_s	Surface area of cell	Calculated based on delineation of nearshore cell boundaries
Variable parameters		
C	Total phosphorus concentration in nearshore cell	Depends on step in analysis
$Load_{in}$	Input load to cell from runoff, septic systems, and groundwater	Depends on step in analysis

Step 1: Evaluate Existing Conditions

The first step of the mass balance analysis includes characterizing the existing conditions of the nearshore cells to define the unknown flow across the cell-lake boundary (Q). It is assumed that there is some flow from the cell to the lake, but the magnitude of the flow from each cell is unknown. Therefore, the equation variables (C and $Load_{in}$) are set equal to values representing existing water quality and loading conditions for the purpose of defining Q.

The maximum observed total phosphorus concentrations for each cell (from Falter et al., 1992) were used to represent existing cell concentrations (C). The existing nutrient loading entering each nearshore cell ($Load_{in}$) was defined based on landuse loading coefficients and estimates of septic system contributions. Phosphorus loading coefficients were identified for each land use in the nearshore drainage area and used with the land use areas draining each cell to determine the total phosphorus load being delivered to the cell through land-based runoff. Loading coefficients and their literature source are listed in Table C-4. Table C-4 also contains an average total phosphorus loading for each of the landuse categories to provide perspective on the relative contributions of total phosphorus within the drainage areas of the nearshore cells. (This average represents the average of the 5 individual "existing" loadings calculated for each nearshore cell used in the TMDL analysis.)

In addition to runoff loading, the $Load_{in}$ parameter includes septic system loading. To estimate the septic system load, the total number of septic systems in the nearshore area was identified based on permits issued by the Panhandle Health District. Table C-5 presents the information used to calculate the loads associated with septic systems for each nearshore cell.

After defining the existing concentrations (C) and the existing loading ($Load_{in}$) for each of the nearshore cells, the mass balance equation is solved for the flow across the cell-lake boundary (Q). Once this flow is defined, the loading capacities can be calculated for each nearshore cell.

Step 2: Calculate Loading Capacity

Now that the flow across the cell boundary (Q) is defined, the constant cell characteristics are established. The next step is to use the mass balance equation to calculate the loading capacity. Because the loading capacity is the allowable load delivered to the nearshore cell, it is represented by $Load_{in}$ in the mass balance equation. The equation's remaining variable parameter must be representative of desired, target conditions to solve for the loading capacity that results in attainment of the water quality standards. Therefore, the cell concentration (C) equals the target total phosphorus concentration of 9 µg/L. The equation is then solved for $Load_{in}$, resulting in the loading capacity for each nearshore cell (Table C-6).

The individual loading capacities were used with the drainage areas for each cell to determine a maximum allowable loading rate for each cell (Table C-6). The average of these rates was then used with the nearshore drainage area to calculate the total loading capacity for the entire nearshore waters of Pend Oreille Lake (Table C-6).

Table C-4. Landuse-specific loading rates used to estimate loading to nearshore cells

Land use name	Land use code	TP Loading rate (lb/ac/yr)	Loading Rate Source	Average TP Loading (kg/yr)[1]
Open Water	11	0.306	Falter and Hallock (1987)[2]	10.88
Low-Intensity Residential	21	0.405	Landon (1977)[1]	11.82
High-Intensity Commercial/Industrial/Transportation	23	0.9	Hoelscher et al. (1993)	18.47
Bare Rock/Sand/Clay	31	0.306	Falter and Hallock (1987)[2]	1.74
Transitional	33	0.9	Hoelscher et al. (1993)	65.21
Deciduous Forest	41	0.081	Hoelscher et al. (1993)	0.37
Evergreen Forest	42	0.081	Hoelscher et al. (1993)	109.98
Mixed Forest	43	0.081	Hoelscher et al. (1993)	2.30
Deciduous Shrubland	51	0.081	Hoelscher et al. (1993)	5.15
Grassland/Herbaceous	71	0.03	Bannerman et al. (1984); Horner et al. (1994)	1.23
Pasture/Hay	81	0.28	Jawson et al. (1982)[2]	78.43
Bare Soil	84	0.306	Falter and Hallock (1987)[2]	0.03
Other Grasses (urban/recreational; e.g. parks, lawns)	85	0.243	Hoelscher et al. (1993)	0.05
Woody Wetlands	91	18	Sonzogni et al. (1980)	14.56
Emergent Herbaceous Wetlands	92	18	Sonzogni et al. (1980)	10.92

[1]Represents average of “existing” loadings calculated for five nearshore sites used in the TMDL analysis.
[2]As cited in Hoelscher et al. (1993).

Table C-5. Information used to calculate septic system loading to nearshore cells

Parameter	Value[a]
Number of people served by system	4
System effluent flow	150 L/person
System effluent total phosphorus concentration	15 mg/L
Soil retention factor for system discharge	0.5

[a] Values contained in Woods (1991b).

Table C-6. Total phosphorus loading capacities for nearshore cells and entire nearshore area

Site[a]	Loading capacity (lb/season)	Allowable loading rate (lb/ac/season)
Oden	614	0.12
Garfield	371	0.08
Talache	358	0.07
Bayview	561	0.11
Lakeview	107	0.08
Entire nearshore area	4,588	0.09

[a] Sunnyside was removed from the analysis because of inconclusive estimation of the flow across the cell-lake boundary. The mass balance equation produced a negative flow across the boundary, indicating that the behavior of the site is irregular and is not appropriately captured in the mass balance assumptions.

Appendix D. Summary of Select Existing Studies on Pend Oreille Lake

Table D-1. Summary of studies of Pend Oreille Lake, Idaho

Study	Summary	Reference
Montana and Idaho Border Nutrient Load Agreement Technical Guidance	An overview document that summarizes data and findings from previous Section 525 studies, as well as others, to determine appropriate water quality targets for the open (pelagic) waters of Pend Oreille Lake. Adopted targets focus on TP concentrations and TP loading from Clark Fork River and the lake's immediate watershed. Water quality monitoring protocols are specified.	TSWQC, 2001
Hydrologic Budgets, Pend Oreille Lake, Idaho, 1989-90	Hydrologic budgets for Pend Oreille Lake and River upstream from Albeni Falls Dam for 1989 and 1990 water years were developed to identify and quantify volumes of water from different sources. The budgets made it possible to relate nutrient concentrations associated with each water source to the volume of water from each source and express that relation as a nutrient load. These data were required as input to the nutrient load/lake response model used to assess open-lake water quality.	Frenzel, 1991a
Nutrient Budgets, Pend Oreille Lake, Idaho, 1989-90	Nutrient budgets for Pend Oreille Lake and River upstream from Albeni Falls Dam for 1989 and 1990 water years were made to identify and quantify nutrient inputs from point and nonpoint sources. These data were required as input to the nutrient load/lake response model used to assess open-lake water quality.	Frenzel, 1991b
Nutrient Load/Lake Response Model, Pend Oreille Lake, Idaho, 1989-90	Report on the application of an empirical nutrient load/lake response model to simulate limnological responses within the pelagic zone to hypothetical alterations in nutrient loadings. Model was calibrated and verified. Using TP and TN loading data collected from 25 tributaries or source areas during the 1989 and 1990 water years, the model simulated the following limnological response variables: Secchi disc readings and concentrations of TP, TN, and Chl *a*.	Woods, 1991b
Phase I Diagnostic and Feasibility Analysis: A Strategy for Managing the Water Quality of Pend Oreille Lake	Provides quantitative information to assess citizen perceptions of degrading lake water quality. The information is a baseline against which historic water quality studies are compared and the effects of future development in the Basin are measured. • Assesses physical, chemical, and biological conditions in lake to characterize water quality changes. • Identifies and quantifies nutrient inputs from natural, point, and nonpoint sources and prepares a mass balance nutrient budget. • Uses a predictive computer model of water quality response to nutrient loads. • Formulates alternative water quality management strategies. • Proposes a comprehensive, long-term water quality management strategy.	Hoelscher et al., 1993
The Nearshore Trophic Status of Pend Oreille Lake, Idaho	Sixteen sites, representative of embayment and open shore habitat, were established around Pend Oreille Lake in 1989 and 1990. Water samples were collected for nutrient and bacteria analyses and physical/chemical limnological parameters. Attached algae were measured. Data were analyzed to determine the extent of eutrophication along the shores of the lake. Chemical parameters did not indicate a problem. In-shore periphyton, however, showed localized advanced eutrophication.	Falter et al., 1992
Water Quality Studies		
Clark Fork-Pend Oreille Basin Water Quality Study	Characterizes water quality problems, identifies sources, and recommends actions for maintaining and enhancing water quality throughout the Basin.	USEPA, 1993
1998 Water Quality Status and Trends Monitoring System for the Clark Fork-Pend Oreille Watershed	An evaluation of water quality data collected in 1998 in the Clark Fork-Pend Oreille Basin. Specifically, statistical analyses presented in this study assess the temporal and spatial variability of nutrient, metal, and algae parameters within the Basin. Five stations in Pend Oreille Lake.	Land and Water Consulting, 1999

1999 Water Quality Status and Trends Monitoring System for the Clark Fork-Pend Oreille Watershed	An evaluation of water quality data collected in 1999 in the Clark Fork-Pend Oreille Basin. Specifically, statistical analyses presented in this study assess the temporal and spatial variability of nutrient, metal, and algae parameters within the basin. Eight stations in Pend Oreille Lake.	Land and Water Consulting, 2000
2000 Water Quality Status and Trends Monitoring System for the Clark Fork-Pend Oreille Watershed	An evaluation of water quality data collected in 2000 in the Clark Fork-Pend Oreille Basin. Specifically, statistical analyses presented in this study assess the temporal and spatial variability of nutrient, metal, and algae parameters within the basin. Eight stations in Pend Oreille Lake.	Land and Water Consulting, 2001

Appendix E. Summary of Public Comments and Responses

This section summarizes the comments received on the draft nutrient TMDL for the nearshore waters of Pend Oreille Lake and TSWQC's responses to those comments (Table E-1).

Table E-1. Responses to public comments received on draft TMDL for nutrients for the nearshore waters of Pend Oreille Lake

	Comment	Response
Gretchen Watkins, 3471 E. Dufort Road, Sagle, ID		
1	In the introduction it states the focus of the plan is to control nutrient loads and eutrophication throughout the basin. Under this statement there are four objectives to protect and restore beneficial water uses. In objective 3, it states: "Reduce nearshore eutrophication in Pend Oreille Lake by reducing nutrient loading". This objective should read: "Reduce nearshore eutrophication and maintain or reduce nutrient loads to protect water quality." The model later illustrates that currently the loads to the lake do not exceed the modeled allowable load for the nearshore area, indicating that the objective is truly to maintain current nutrient.	Objective 3 was taken directly out of the *Clark Fork-Pend Oreille Basin Water Quality Study: A Summary of Findings and a Management Plan* (US EPA, 1993). The nearshore TMDL has been designed to meet this objective. We have set a target of 9 µg/L to prevent nutrient rates from increasing, and the action threshold of 12 µg/L will very likely require reductions in order to meet the target and protect water quality. Follow-up monitoring will help us evaluate where and to what extent these reductions will take place. It is important to note that the full objective reads: "Reduce nearshore eutrophication in Pend Oreille Lake by reducing loading *from local sources*." Since there is not currently any concerted effort to reduce loading from nutrient sources in the lake's watershed, it is the focus of the TMDL to ensure that these local sources are addressed.
2	The primary target of 9ugL-1 was chosen to represent the average concentration throughout the nearshore water. This does not support objective 3, which is intended to reduce nearshore eutrophication by reducing nutrient loading, because we have chosen the primary target at the current levels. This target level does not provide any benefit to water quality other then maintaining it.	Objective 3 was taken directly out of the *Clark Fork-Pend Oreille Basin Water Quality Study: A Summary of Findings and a Management Plan* (US EPA, 1993). The nearshore TMDL has been designed to meet this objective. Although derived from data assumed to represent current levels, the target of 9 µg/L and the action threshold of 12 µg/L will very likely require reductions to meet the target and protect water quality. The targets are designed to maintain water quality in areas of the lake where current levels are protective of designated uses and to reduce nutrients in the areas where levels are impairing uses. Nearshore nutrient data collected in 1991 indicate that reductions will likely be necessary to meet the targets. Follow-up monitoring will be used to evaluate where and to what extent these reductions will take place.
	I think it would be valuable to state some common accepted limnological principles about trophic state (lake productivity) classification based on total phosphorus concentration (Vollenwider, 1968).	Additional information on the relationship between phosphorus and the trophic status in lakes has been included in the report (as Appendix B) to provide more background information and context for the Pend Oreille nearshore TMDL target.
	It would also be beneficial to state that chlorophyll a and phosphorus are correlated in fresh water systems (Bartsch and Gaketatter, 1978) and this is why 9ugL-1 was chosen and not because it was the average concentration in the nearshore water of Lake Pend Oreille.	The assumed correlation of phosphorus and algal growth (and chlorophyll a) was one of the reasons for choosing total phosphorus as the TMDL target parameter. The primary reason was because the lake has been documented as being phosphorus-limited and, additionally, phosphorus data were readily available for the nearshore areas of the lake. However, these reasons were not the basis for the identification of the specific target value of 9 µg/L. The target of 9 µg/L was identified through evaluation of the frequency of occurrence of observed total phosphorus concentrations and is not the average of observed concentrations.
3	I am concerned that the model is too simplistic. The part I have the most trouble with is that mixing was not taken into account between the nearshore cell(s) and the open water. I think the model should account for advection/diffusion across the nearshore and open water boundary.	To develop the TMDL for critical conditions the model was developed for the conditions of maximum potential algal growth—summer conditions with warmer temperatures and less mixing. The model conditions were established as more conservative than the likely critical conditions (i.e., no lake-to-cell mixing) to provide a margin of safety. The model accounts for flow from the nearshore cell to the open waters but not into the nearshore cell from the open waters. This is a conservative assumption and provides a margin of safety in the TMDL. The target for the open waters of the lake is 7.3 µg/L. Because the nearshore target is 9 µg/L, mixing from the open waters to the nearshore would result in dilution of the nearshore waters and an increase in allowable nearshore loading. Restricting mixing to unidirectional flow out of the nearshore cells provides a lower loading capacity and an implicit margin of safety.

Comment		Response
	I was also uncertain if there is only one cell that represents the nearshore zone. If this is true I think this model should be rewritten so that there are multiple cells along the shore. Hopefully delineated along hot zones. If the model is currently written for one cell to represent the whole nearshore area, you are saying that Sunnyside completely mixes with Lakeview and not at all with the open water. This would not make any scientific sense and in such a case the model should be rewritten. Rewriting the model to account for multiple cells would allow the restrictions to be more stringent if we isolate nutrients coming from heavily populated areas and not model them to mix with the whole nearshore area. If the model is written with multiple cells along the nearshore, they should be mixing by diffusion to be accurately portrayed.	The mass balance analysis was applied separately to multiple representative nearshore cells to identify an overall loading capacity for the nearshore waters of the lake. The water quality and loading conditions at six nearshore cells were used to evaluate their associated loading capacities for total phosphorus. Those six loading capacities were used to calculate associated loading rates (kg/acre/season) for each cell. The average of the six loading rates was used to calculate an overall average loading capacity for the entire nearshore area. Therefore, the mass balance analysis does not assume mixing among the evaluated cells—they are evaluated as independent cells with unique characteristics (e.g., water quality, volume, loading, flow, etc.) and drainage areas. Multiple cells were used to evaluate a range of conditions throughout the lake's nearshore, but the TMDL does not identify specific loading capacities or allocations by area. The TMDL represents an overall loading capacity for the entire nearshore area.
4	In the monitoring section we should add monitoring of currents, pH, ionic strength, and temperature to better understand the mixing of the lake and make the model more predictive. I suggest you propose a volunteer-based monitoring program be initiated.	During 2002, the Tri-State Water Quality Council's monitoring committee will be developing a monitoring program for Pend Oreille Lake. It is very likely that monitoring for pH and temperature will be included in the program, as sampling for these parameters can be accomplished readily through use of a HydroLab unit. Monitoring of currents and ionic strength would not be feasible at this time given the level of funding or resources available; monitoring on these two parameters would not be needed unless a more complex model were to be developed in the future, which is not likely. A citizens' volunteer monitoring program was implemented a number of years ago on the lake which included sampling for water clarity and nutrients. Currently, volunteers monitor water clarity from spring through fall. Depending on final design plans and availability of interested volunteers, citizen volunteer monitoring will very likely be an important part of the lake monitoring program.
5	In the section on non-point source controls, I would like to see more in the education section. Public education and outreach is key to successful management of nutrient input. Arranging public talks on watershed protection, establishing outreach programs in local schools, and recruiting volunteers to help with restoration projects and water quality monitoring are effective ways to engage the community in protecting their resource. Roads are a proven source of phosphorous-laden sediment to our waterways. Therefore you should suggest paving roads, and constructing swells and ditches along roadsides to catch storm water runoff. Recommendations calling for a spring sweep of the roads and require only clean and large particle de-icers be used would be vital in controlling the eutrophication of Lake Pend Oreille.	The public education section presented in the TMDL is intended as a brief overview of the types of programs that will be developed in the TMDL implementation plan. Once EPA approves the lake nearshore TMDL, a committee will be established to develop an implementation plan and a comprehensive public education program will be at the heart of this plan. Regarding roads, Bonner County currently has a citizens' advisory committee working to come up with a long-term plan to address impacts from roads. We plan to have representatives from this group become involved in developing the TMDL implementation plan, so that specific action items for mitigating for roads can be included.

	Comment	Response
Radley Watkins, 3471 E. Dufort Rd., Sagle, ID 83860		
1	I am in favor of establishing a TMDL for phosphorus (P) for Lake Pend Oreille, in Bonner County, Idaho. I have one comment to be submitted to the record: As I understand it the water quality of Lake Pend Oreille was progressively getting worse, with frequent algae blooms observed in the near shore areas and the diminishing water quality caused the lake to be listed as threatened by the EPA. The proposed TMDL would be set to maintain a phosphorus (P) concentration of 9 micro grams per liter in the near shore areas. This level is below the current level of P loading into the lake. How is it that the we are proposing to set a TMDL, a standard, that is allowing more pollution to enter the lake than is presently entering the lake, when the current level has caused the water quality to deteriorate to the point at which the lake is considered threatened? I do not believe we can defend a TMDL that is allowing more P to enter Lake Pend Oreille than is already entering the system, if the current level is contaminating the water to the point that the lake is threatened.	The proposed TMDL is designed to maintain phosphorus concentrations at current levels only where they are at or below 9 micrograms per liter on average in the nearshore areas. Based on data collected in 1991, the TMDL will likely require reductions in nutrients in some areas of the lake. Pend Orielle Lake is the largest and deepest lake in Idaho with considerable variability in nutrient levels. The TMDL attempts to address the entire lake with one target level for total phosphorus and is written to maintain nutrient levels where they are not impairing beneficial uses and reduce nutrient levels in areas where they are. The TMDL implementation plan will include sampling for nutrients in the lake creating a more comprehensive data set that can be used to alter the TMDL as necessary to protect beneficial uses. The comment that the TMDL will allow more pollution to enter the lake than is presently entering the lake is not correct.
Jane Fritz, P.O. Box 388, Clark Fork, ID 83811		
1	I am writing to support the proposed nutrient Total Maximum Daily Load (TMDL) for the near shore areas of Lake Pend Oreille. As someone who has lived in the area for over 20 years and who regularly canoes the near shore areas around the Clark Fork Delta, Hope Peninsula, and Green Monarch Mountains, I know firsthand the rapid decline of the Lake's water quality and the urgent need to reduce pollutants and to raise the Lake's water quality standards. Twenty years ago, the underwater stones a few feet from shore at my favorite rock beach along the Green Monarchs were squeeky clean and the water clean enough to drink. Now the rocks are consistently covered with algae and scum and one day last summer the water smelled like a cesspool and I was afraid to swim in it. This beach is only accessible by boat, so I can't imagine what the water quality is like in places like Ellisport Bay or near Trestle Creek. Something must be done now to protect the lake or 20 years from now, Lake Pend Oreille will be a sewer in the shallow areas around its shoreline. I believe the Tri State Council has done a good job working with the federal EPA and the state DEQ to develop the Lake Plan. Now, I hope it can be implemented, and soon. Hopefully, the public will comply with any regulations to protect and improve the Lake's water quality. I will do what I can to get the word out. One area that the public really needs educating is how close to the water's edge one should build a fire. I am constantly dismantling fire rings five to ten feet from the water's edge so to discourage the next campers from building new fires. When I have an opportunity, I inform people about how this is contributing to the pollution of Lake Pend Oreille. Some people don't want to hear that and get nasty. I think DEQ and TriState Council could do a better job of educating recreationists about fires along the lake shore in the new plan.	As noted above, once EPA approves the lake nearshore TMDL the next step will be development of an implementation plan. The plan will include a number of measures to protect and improve nearshore water quality. Enforcement on some of these actions may prove difficult, that is why education will be the most critical component of the plan.
Bryan Rowder via email at browder@mindspring.com		
1	Because of millions of factors in water pollution, what we humans consider the most damaging potential in our perceptions, is to be addressed. I applaud everyone involved to figure this out and work to achieve the goals, and thank you.	Thank you for your involvement.

	Comment	Response
Scott Dunn, 1507 Northshore Dr., Sandpoint, ID 83864		
1	The TMDL should include experience on other similar bodies of water regarding TMDL targets, algae growth expectations, known scientific experience at the different TMDL targets. It would give the reader an idea of what one could expect. It would also be useful to breakdown the contributors to load, background natural rates, rates that are realistically achievable, etc. Keep up the good work!	Additional information on phosphorus targets recommended in literature and used in other TMDLs has been included as an appendix in the TMDL report (Appendix C). Also, to give an idea of the distribution of loading among watershed sources, Table B-1 in Appendix B (now Table C-1 in Appendix C) has been modified to include average “existing” phosphorus loadings from different land uses within the drainage areas of the nearshore cells used in the TMDL analysis.

Appendix F. Summary of Existing TSWQC Monitoring

As part of its watershed management program, the TSWQC implements water quality monitoring to collect, analyze, and distribute information on the status and trends of water quality in the watershed. Eight water quality monitoring objectives include sampling for nutrients and metals at sites along the mainstem of the Clark Fork River, Pend Oreille Lake, and the Pend Oreille River, and sampling for algae in late summer at sites on the Clark Fork River and Pend Oreille Lake. The parameters sampled annually for Pend Oreille Lake are

- Nutrient loading from the Clark Fork River: Phosphorus and nitrogen (total and soluble), 18 samples collected at Cabinet Gorge (12 monthly samples plus 6 additional samples during two-week peak flow period).

- Attached algae: 5 in-lake stations sampled during peak growing season (mid-September) utilizing templates of 10 replicates per site.

- Trophic status: Secchi depth measured at three sites (Hope, Granite, and Bayview) monthly from spring through fall.

In accordance with the *Montana and Idaho Border Nutrient Load Agreement: Technical Guidance* (TSWQC, 2001), the TSWQC will undertake additional work to

- Estimate annual total phosphorus loads to the lake from the Clark Fork River (from data collected at Cabinet Gorge).

- Assess open water lake-wide average total phosphorus concentrations in the euphotic zone (from additional data collected at two sites, Hope and Granite).

- Assess trends in lake trophic status using the Carlson Index (total phosphorus, Secchi depth, and chlorophyll *a*).

Appendix G. List of Acronyms

Acronym	Full Phrase
TMDL	Total Maximum Daily Load
TSWQC	Tri State Water Quality Council
MOS	Margin of Safety
EPA	Environmental Protection Agency
USEPA	United States Environmental Protection Agency
IDEQ	Idaho Department of Environmental Quality
MSL	Mean Sea Level
PHD	Panhandle Health District
NRCS	Natural Resource Conservation Service
ITD	Idaho Transportation Department
IDL	Idaho Department of Lands
SWCD	Soil and Water Conservation District
USACE	United States Army Corps of Engineers
TSI	Trophic Status Index
TN	Total Nitrogen
TP	Total Phosphorus
Chl *a*	Chlorophyll *a*

Appendix H. Glossary of Terms

This glossary includes a collection of the terms used in this document and an explanation of each term. To the extent that definitions and explanations provided in this document differ from those in state and federal regulations or other scientific documents, they are intended for use in understanding this document only.

- **Total Maximum Daily Load** – A pollutant budget most simply expressed in terms of loads through quantities or mass of pollutants added to a waterbody. According to EPA regulations and guidance, this budget takes into account loads from point and non-point sources, and human-caused as well as natural background loads.
- **Section 303(d) list** – A list of all waterbodies not meeting state water quality standards in accordance with the Clean Water Act of 1972 required to be developed every two years.
- **Total Phosphorus –** Includes: orthophosphates, condensed phosphates, and organic phosphates.
- **Wasteload Allocation –** The proportion of a receiving water's total maximum daily load that is allocated to one of its existing or future point sources of pollution.
- **Load Allocation –** The proportion of a receiving water's total maximum daily load that is allocated to existing or future non-point sources.
- **Pelagic Zone –** The area of a lake beyond the influence of the bottom (i.e., open lake waters).
- **Littoral Zone –** The zone extending from the shoreline to a depth where the light is barely sufficient for rooted aquatic plants to grow.
- **Oligotrophic** – A term applied to freshwater lakes where nutrients are in short supply (little nourished).
- **Mesotrophic –** A term applied to freshwater lakes where nutrients are available but not abundant (moderately nourished).
- **Meso-oligotrophic** – Between oligotrophic and mesotrophic.
- **Intermittent Streams** – A stream that only flow for part of the year, as after a rainstorm.
- **Aquifer –** A geologic unit that can store and transmit water.
- **Morphometry** – The shape of a lake basin.
- **Hydraulic Retention Time** – The time required for all the water in the lake to pass through the outflow.
- **Thermal Stratification** – The distribution of heat within a lake forming separate strata based on water temperature.
- **Aquatic Macrophytes** – Large water plants that are either free-floating or rooted.

- **Steady – State** – Assumes no change with time.

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